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**CUMBERLAND PLATEAU  
SEISMOLOGICAL OBSERVATORY**

**Quarterly Report No. 5  
1 August through 31 October**

**9 November 1966**

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## SECTION I

### INTRODUCTION

This report reviews the operations and research work conducted by Texas Instruments Incorporated during August, September and October 1966 on the Cumberland Plateau Observatory (CPO) contract. Efforts during the quarter have been directed toward routine observatory operations, Dallas and station-conducted research tasks and construction and checkout of a detection and identification digital processor.

Operation of CPO during the reporting period has continued on a routine basis. The overall observatory maintenance configuration has remained good with minimum station downtime resulting from a continual preventive maintenance program. Magnetic tape and film data have also been high-quality.

Research activities during this quarter have concentrated on evaluation of the MCF processor, ambient noise studies, detection processor research and a study to improve visual data displays. As in Quarterly Report No. 4\*, additional data are presented to demonstrate the increase in station detection capability as a result of on-line MCF processing.

As of 31 October, construction of the auxiliary processor was complete, the basic MCF had been modified to interface with the auxiliary processor and separate checkouts of the two units had been completed. The next phase is to interface the units and conduct system checkout.

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\* Texas Instruments Incorporated, 1966: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 4, Contract No. AF 33(657)-14648, 28 Oct.



## SECTION II

### OBSERVATORY OPERATIONS AND RESEARCH

This section presents results concerning CPO station operations and research during the past quarter. Included are the station downtime data for the quarter and reliability information on the MCF processor.

#### A. STATION ANALYSIS

Station analysis has proceeded on schedule. Data recordings have been good with the only problems being a few instrument failures. Of these problems, the most important was data loss due to inoperability of the long-period Develocorder for four days during October (Subsection IIC-2). The number of events recorded during the quarter are as follows:

<u>Month</u>	<u>Teleseisms</u>	<u>Regionals</u>	<u>Near-Regionals</u>
August	599	8	—
September	635	7	—
October	601	8	2

Included in Section III is a discussion of the number of events reported during August with and without the use of on-line processed data from the MCF.

Of particular interest in the station analysis during the quarter was the Peruvian earthquake of 17 October. During this period at the station, this was the largest event recorded. It has 1049.4 mm of ground motion and a magnitude 6.3. The direction of the event was SSE from CPO at an epicentral distance of 43°. Table 1 presents the phases reported by station analysts.

#### B. STATION RESEARCH

Station research during the reporting quarter has been directed primarily toward evaluation of the MCF processor. This has included a study of the increase in detection capability afforded the station by the MCF and a study of the MCF hardware reliability.

#### C. STATION INSTRUMENTATION

##### 1. General

The station engineering section has continued routine preventive maintenance procedures during the past quarter; however, two problem areas did arise which hampered routine station analysis and operations (Subsection IIC-2). As in the last quarter, routine quality control has also indicated minimal problems with tape and film data during the reporting period (Subsection IIC-2).



Table 1  
PHASES RECORDED AT CPO FROM PERUVIAN EARTHQUAKE  
17 OCTOBER 1966

<u>Phase</u>	<u>Recording Instrument</u>	<u>Time</u>	<u>Remarks</u>
iP	JMZ	21:50:21.3	compression wave, 1049.4-mu ground motion
eP	LP's	21:50:21.3	
pP	JMZ	21:50:37.2	1.7 second period amplitude 999**
e*	LPZ	21:52:02	
e	JMZ	21:52:46.7	
e	LPZ	21:53:21	
e	LPZ	21:54:11	
e	JMZ	21:56:06.8	
S	LPH	21:56:37	amplitude 999
S	SPH	21:56:39.9	amplitude 999
SS	LPE	21:59:36	amplitude 999
LR	LP's	22:00:51	amplitude 999
e	JMZ	22:01:38.1	
e	JMZ	22:01:50.6	

\* e indicates a phase was recorded but not identified.

\*\* Amplitude 999 signifies the phase was clipped.



Another serious problem, failure of the air-conditioning system, was encountered at the station during the quarter but resulted in no loss of data. The system was out on August 28 for replacement of a worn shaft on the heat exchanger and on October 9 when a direct lightning strike destroyed the starting circuit and compressor motor.

Other engineering accomplishments and problems during the quarter were:

#### August

- No. 4 Develocorder installed at station. This Develocorder will allow output recording from both the MCF and auxiliary processor when they are installed
- A-C power connections on Develocorders standardized
- Tube replaced in Z15 PTA
- Tube replaced in Z12 PTA power supply
- Replaced chemical pump on Develocorder No. 2
- Replaced inlet valves and seals in two chemical pumps
- Maintenance performed on Develocorder No. 2 date-timer
- Adjusted long-period seismometers
- Performance of equalizations and d-c pulses on all systems
- Test calibrations and pulses performed on Z6 and Z7 to check polarity
- Frequency responses on Z1 - Z19, SPN and SPE
- Maintenance on FM discriminator Tape No. 2 to remove d-c offset from output
- Performed d-c pulses on all seismometers
- Weight lifts, pulses and free periods performed on Z1 - Z19, SPN and SPE. G's adjusted on Z4, 7, 9, 10, 13, 14, 15, 16, 18 and SPE
- Function generator malfunctioned and was repaired
- Z15 and Z16 damping pots replaced in data line terminal modules
- Maintenance performed on bias oscillator Tapes 1 and 2



## 2. Major Accomplishments and Problems

Two problem areas did arise which affected station recordings during the reporting period. The first involved the data recorded from Seismometer Z10. The problem was leaking of current in the cable which gave erroneous calibration values. This problem existed during July and August before it was independently discovered through routine FM-tape quality control and through computing calibration analysis in support of the ambient noise studies. The erroneous calibrations affected the absolute level of the single-channel power density spectra for this time period (Subsection IIIB-1). The problem was corrected by replacing bad sections in the cable and by replacing the Z10 data line terminal module which was found to have defective damping pots.

The second major problem area was the loss of data due to the failure of the long-period Develocorders. The Develocorder was inoperative during the following periods for the reasons stated:

- October 18, 15:37 to October 19, 16:25  
Drive motor went out and was repaired
- October 21, 10:38 to 15:40  
Drive motor went out and was repaired
- October 21, 18:05 to October 22, 16:10  
Intermittent work and replacement of shaft
- October 29, 01:37 to 23:36  
Motor was removed and replaced with a spare

Also, during the reporting period, the following minor difficulties were encountered:

- September 22  
Z2 was out for 4 hr for cable splicing
- October 5  
Channel 3 on Tape 1 and Z2 were out for 1-1/3 hr for module maintenance
- October 19  
Z6 was out for 4 hr for cable splicing



### September

- Z4 removed from operation to correct sticking mass, repaired, and replaced on-line
- Frequency responses, d-c pulses and equalizations performed on all seismometers
- Performed LPZ maintenance at vault and checked out PTA
- Changed trimpots on channels 9 and 10, Tape 2, and channel 3, Tape 1
- Completed testing and crating of the MCF for shipment to Dallas; unit shipped on 1 October

### October

- Data line terminal module box preventive maintenance performed
- All calibration and data cables checked at central recording building for shorts and bad grounds
- Performed maintenance on spare short-period seismometer
- Rewired calibration switching unit
- Preventive maintenance performed on Develocorder No. 1
- Develocorder coding units checked for proper codes and cleaned
- Long-period seismometer adjusted
- Winterizing of long-period seismometers and preventive maintenance of bad spots in cables performed



The removal of the MCF from the station operating configuration on 30 September left unused channels on the Develocorders and magnetic tapes for several outputs. The new trace assignments, as approved by the Project Monitor, are shown in Table 2.

Table 2  
DATA FORMAT ASSIGNMENTS

Channel Number	Develocorders				Magnetic-tape Recorders	
	Data Group 6000	Data Group 6032	Data Group 6025	Data Group	Data Group 6017	Data Group 6031
	No. 1 & 2 SP Primary	No. 1 & 2 SP Secondary	No. 3 LP Primary	No. 4	No. 1	No. 2
1	V	V	WI		TCDMG	TCDMG
2	Z7	$\Sigma$ I	MS		Z1	LPZ
3	Z1	$\Sigma$ K	ZLL		Z2	LPN
4	Z4	$\Sigma$ L	NLL		Z3	LPE
5	Z2	$\Sigma$ T	ELL		Z4	SPN
6	Z3	$\Sigma$ TF	ZLP		Z5	SPE
7	Z5	$\Sigma$ D	NLP		Comp.*	Comp.*
8	Z6	$\Sigma$ E	ELP		Z6	BBZ
9	Z9	$\Sigma$ H	ML		Z7	$\Sigma$ D
10	$\Sigma$ L	$\Sigma$ G	Z8		Z8	$\Sigma$ E
11	$\Sigma$ TF	Z10	WWV		Z9	$\Sigma$ G
12	$\Sigma$ T	ZSL	-		Z10	$\Sigma$ H
13	Z8	Z8	-		$\Sigma$ TF	$\Sigma$ T
14	NSP	NSP	-		WWV & Voice	WWV & Voice
15	ESP	ESP	-			
16	WWV	WWV		WWV		

\* Compensation





### 3. MCF Maintenance and Reliability

Required maintenance effort on the MCF processor has been minimal during the reported quarter. The major engineering effort expended on the MCF has been directed toward solution of the coefficient loss problem. The probable cause of this problem has been identified, and a modification was designed, installed and tested in the unit. Results of these tests indicated that the modification is suitable.

#### a. Hardware Reliability

MCF reliability data for August and September\* indicate that the unit was inoperative less than 0.01 percent of the total operating time. This includes downtime for routine, preventive and unscheduled maintenance. No component replacements, which would affect the MCF basic performance, were required during this period.\*\*

A meaningful maintenance and reliability guide which is used in judging hardware performance is the "mean time between failure" (MTBF). The MTBF for the MCF has been computed with the following results:

- MTBF of 429.8 hr for the period 18 March 1966 to 30 September 1966
- MTBF of 900.0 hr for the period 19 May 1966 to 30 September 1966 (i. e., period following "infant mortality"\*\*\*)

It should be noted that, in computing MTBF data, only those component failures and other maintenance problems which directly affect basic operation of the hardware as an MCF are considered. Thus, problems which might exist in the paper tape reader, printer and blower system would not affect the MTBF.

The MTBF of 900 hr after the infant mortality period means that on the average a component failure or other maintenance problem could be anticipated at 37.5-day intervals. This is somewhat above the original theoretically derived result of 277 hr. MTBF data on the MCF will continue to be updated when the MCF is returned to on-line operation at CPO. Similar data will be compiled for the auxiliary processor.

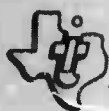
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\* Data for October are not available since the processor was returned to Dallas on 1 October for auxiliary processor retrofit and checkout.

\*\* The paper tape reader did require some part replacement and maintenance, but this unit does not affect the MCF basic routines or outputs.

\*\*\* The "infant mortality" period was chosen as 2000 hr and is normally considered the "shakedown" period in which marginal and bad components are identified and replaced and other maintenance problems normally appearing in new equipment are corrected.





#### b. Coefficient Loss Problem

Since the installation of the MCF at CPO in March 1966, there has been a sporadic loss of filter coefficients which theoretically would void the output of the affected channel. Such a loss should not occur in the hardware under operating conditions which normally exist at a remote observatory.\* Considerable effort has been directed toward determining the problem cause. Identification of such a problem is difficult since the chance of isolating the conditions which might effect a loss is reduced due to the sporadic nature of occurrence and to the extremely short time periods (2 to 200- $\mu$ sec range) in which the loss could occur. Initial efforts were directed toward insuring that the MCF was operating as designed. This was accomplished by replacing several marginal and bad components in May 1966.\*\* The internal and station electrical ground paths were changed to insure that ground-loop problems, which could cause a coefficient loss, did not exist.

Since data collected under conditions existing at the time of a coefficient loss indicated a strong correlation of loss to local electrical storms, an attempt was made to simulate conditions, similar to those which might exist during such storms, on the MCF power and data line inputs. Over-voltage placed on the line had no effect on loss. However, when a power dropout of short duration (approximately 5 msec) was created on the input power line, a 50-percent occurrence of coefficient loss was obtained.

Further investigation revealed that the short duration line power dropout could cause a marginal +4-v logic power supply which would be too brief to be detected by the memory data-save. The marginal logic supply could then cause a dropout or miscount on logic commands to the memory which would affect the memory read/write routine, thus creating a coefficient loss. A modification has been incorporated into the MCF to avoid this condition. The modification monitors the +4-v supply and places the MCF in "stop" during short-duration transients which were not previously detected by memory data-save. The minimum time the unit is required by this circuit to remain in "stop" is 100 msec, or two frame times. Laboratory tests have shown that the addition of this modification prevents coefficient losses resulting from short transients. The next evaluation phase of the modification will be on-line testing at CPO which will begin in January. The modification will also be tested for a no-delay condition to determine if the 100-msec delay requirement can be deleted.

\* Specification for Advanced Multichannel Filter 563992-2, TI Drawing No. 555702, 3 June 1965, paragraph 3.3.5.3.5.

\*\* Texas Instruments Incorporated, 1966: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 4, Contract No. AF 33(657)-14648, 28 Oct.



A more detailed discussion of the coefficient loss problem and the modification is provided in Appendix A along with a discussion of the effect that coefficient losses have on MCF output data.

#### D. QUALITY CONTROL

Routine quality control procedures for FM magnetic tape Develocorder film data have continued on a spot-check basis throughout the recording period as outlined in previous reports.\* Results of this effort have been beneficial in determining problems which existed with the FM tape data and station instrumentation.

Generally, the quality of the film data has been good, primarily as a result of the Develocorder overhaul program (discussed in CPO Quarterly Report No. 4). Analysis form completion has been accurate and neat, and the only real problem encountered on the film data was as a result of the LP Develocorder failure which was discussed under station instrumentation.

During the period reported, magnetic tape data were in good overall condition. The tapes appeared serviceable, and very few spikes were observed during the tape spot-checks. The results of the QC effort for the period are summarized below:

- Wow and flutter consistency within tolerance on both transports
- VTC was consistently good, but on occasion WWV was noisy, probably due to radio interference
- VTC and WWV were aligned in time on all records checked
- Average frequency measurements showed all channels to be within tolerance of center frequency, with the exception of Channel 13 on run C6-233-1. This was immediately corrected.
- Tape calibration checks were within tolerance
- Seismometer calibration checks pointed out the problem with Z10 which is discussed under Subsection IIC

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\* Texas Instruments Incorporated, 1965: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 1, Contract AF 33(657)-14648, Aug. 8, p. II-7.

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## SECTION III

### RESEARCH

#### A. GENERAL

This section reviews the research performed on the CFO contract during the reported quarter. The research activity is divided into four areas and is basically oriented toward improvement of station detection capability. These areas are the continuation of the ambient noise study, the auxiliary processor, an MCF evaluation study, and a study of visual data display improvement. A general description of each of these tasks follows.

- Continuation of Ambient Noise Study

The purpose of this task is to insure time-stationarity of the major contributors to the CPO organized ambient noise field. This task is studied through the computation of single-channel power density spectra and multi-dimensional frequency-wavenumber spectra.

- Auxiliary Processor

This task includes the design and construction of a real-time detection and identification processor which interfaces with the existing MCF. The task includes research on the operating parameters of the processor and an evaluation of the effects on the output data of assumptions used in the processes. Once the processor is operating on-line, an evaluation of its effectiveness as a detection tool will be conducted.

- MCF Evaluation Study

This study is being performed to determine the increase in detection capability in analysis work afforded the station personnel through the use of the MCF. As was outlined in Quarterly Report No. 4\*, this task is being accomplished through the compilation and analysis of two lists of events.

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\* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.



These lists are studied to compare the number of events reported with and without the use of MCF data in routine analysis.

- Visual Data Display

Various methods for improving visual data display will be developed and evaluated under this task. Ultimately, techniques will be recommended to improve analyst use of film data. Two approaches being investigated at present are the design of single-channel filters to remove the system amplitude and velocity responses and the processing of CPO data through various playback techniques to improve the display features.

## B. AMBIENT NOISE STUDY

This subsection compares the properties of the present CPO noise field with those noted previously (May 1965 to July 1966) to ascertain if the noise field, as previously modeled, has changed enough to affect the performance output of the MCF coefficients. Since May 1966 this study has included the computation of one single-channel power density spectra per week and one multidimensional frequency-wavenumber spectra per month. The study will continue on this schedule through April 1967.

### 1. Single-Channel Power Density Spectra

At present, the data for this study have been processed through August, with the September data currently being analyzed. As mentioned in Section II, the calibrations to channel Z10 during the months of July and August, as reported on the daily calibration logs, were incorrect due to cable and instrumentation problems, and accurate absolute ground-motion levels could not be placed on the spectra. However, the shape of the spectra is correct and can be analyzed for changes in spectral shape or predominate features.

The single-channel power density spectra for the months of July 1966 and August 1966 are shown in Figures III-1 and III-2, respectively. The general shapes of these spectra do not differ appreciably from those presented in CPO Quarterly Report No. 3. However, of particular interest

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\* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 3, Contract AF 33(657)-14648, 29 Mar.

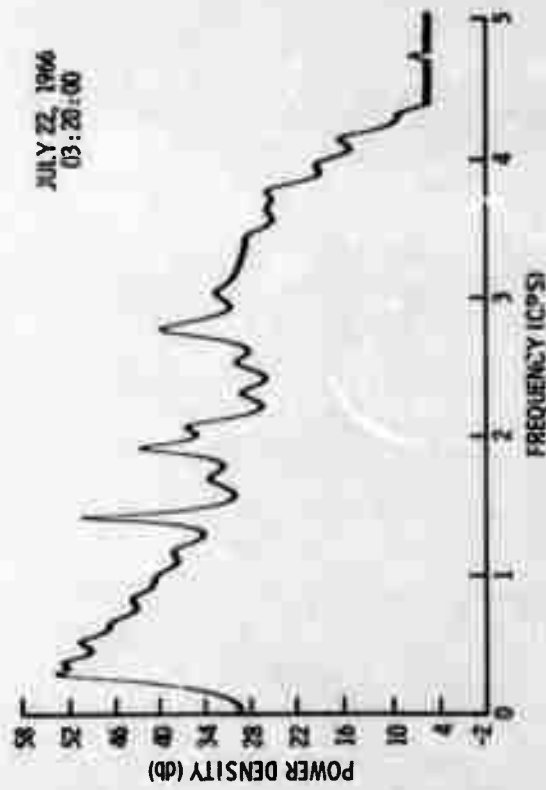
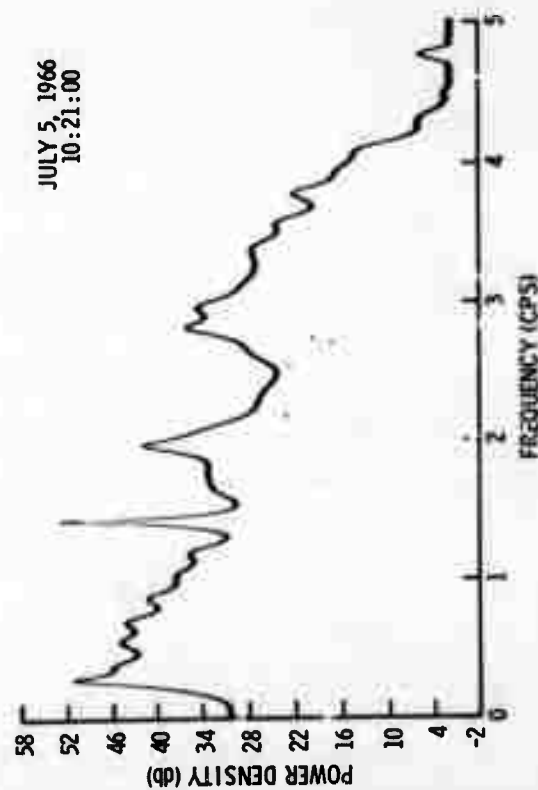
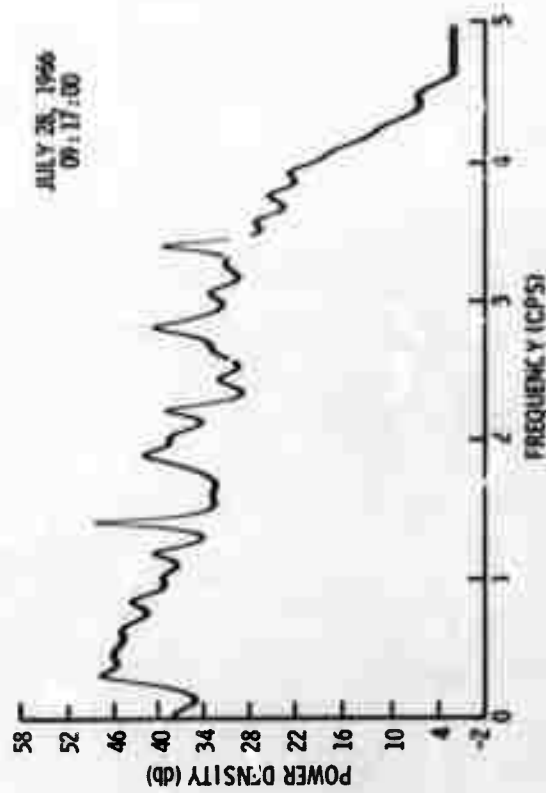
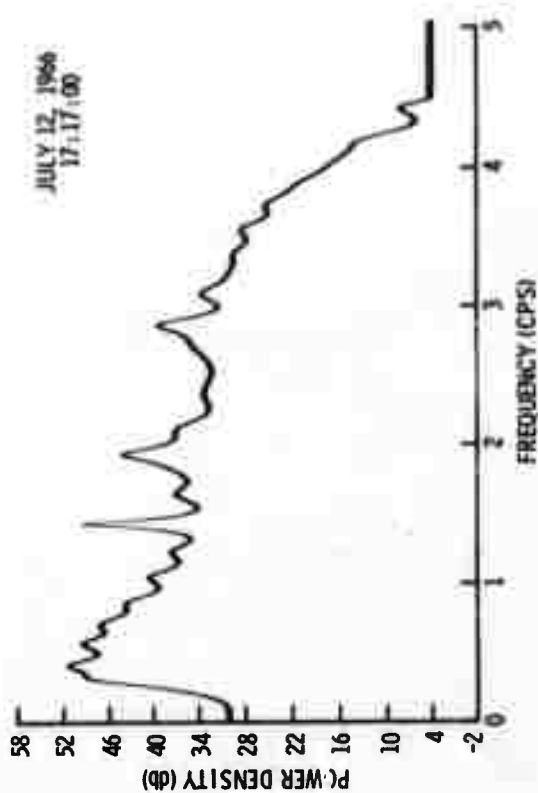


Figure III-1. CPO Ambient Noise Power-Density Spectra for July 1966

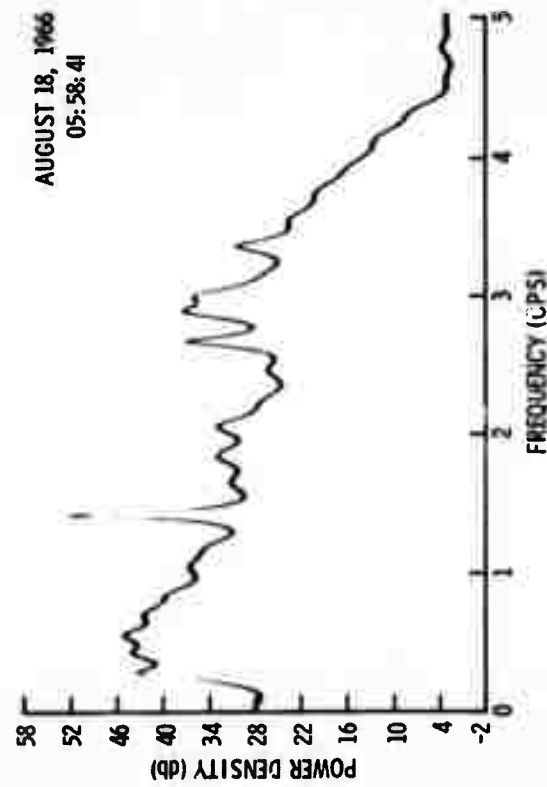
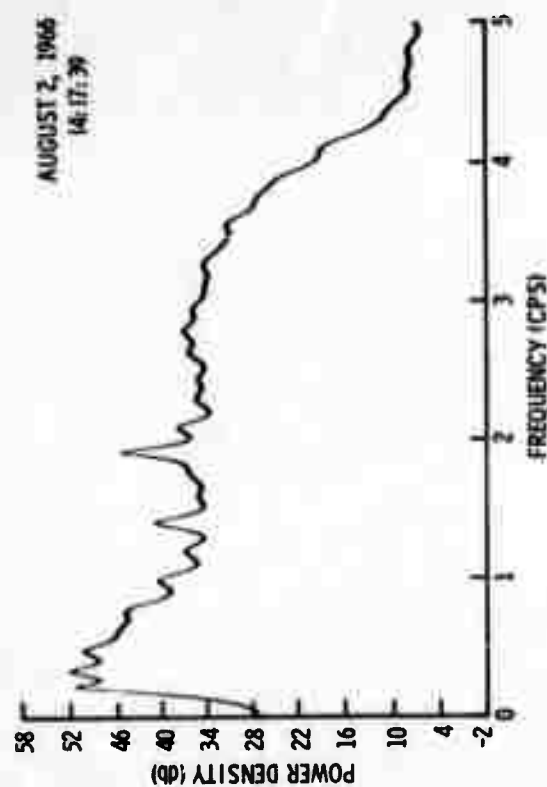
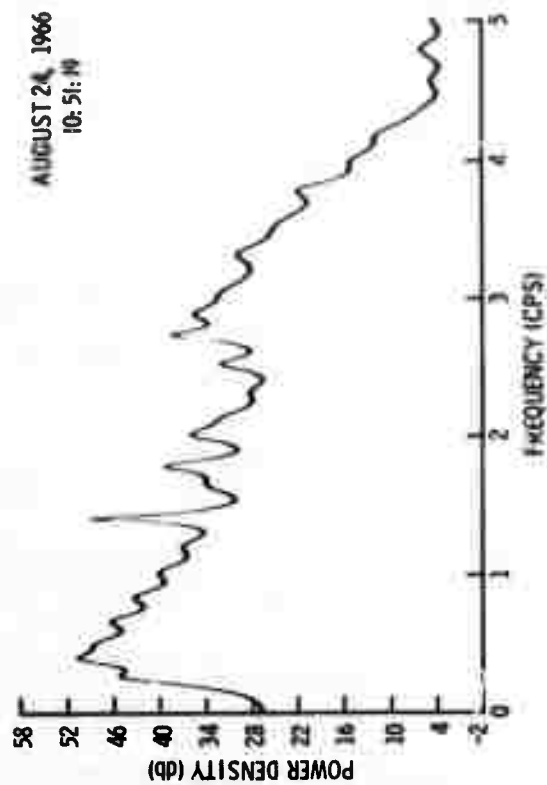
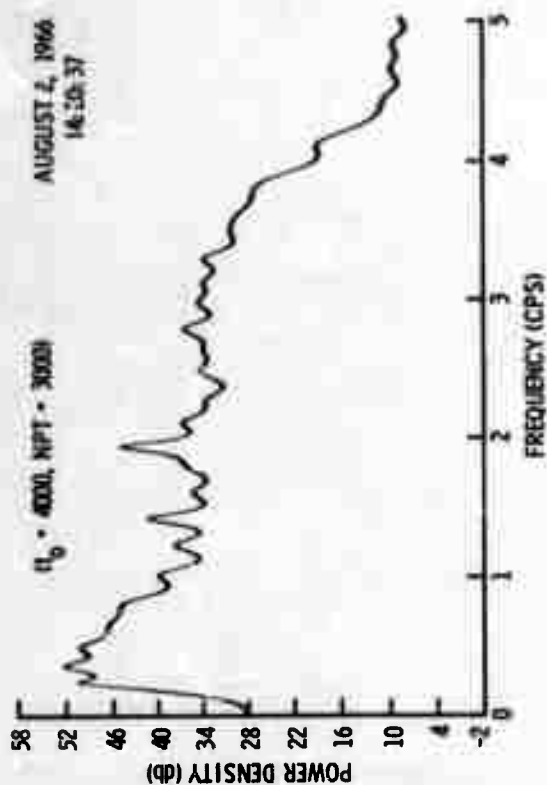


Figure III-2. CPO Ambient Noise Power-Density Spectra for August 1966





is the high level of the peaks at 1.4 cps, as shown in the spectra for July 5 and August 18. This peak is approximately 24 db above the average noise level for these days, while the highest level shown in CPO Quarterly Report No. 3\* on 13 August 1965 is 15 db above a comparable level.

Although this result would tend to indicate a change in the noise field, such a conclusion is unwarranted since this peak has been observed before and varies considerably in level. Further discussion of the 1.4-cps peak is presented under the section dealing with  $f$ - $\vec{k}$  spectra.

## 2. Frequency-Wavenumber Spectra

The data presented in the 3-dimensional frequency-wavenumber spectra in Figures III-3 through III-7 for 5 July 1966 and 18 August 1966 do not differ significantly from those presented in previous quarterly reports, thus indicating time-stationarity of major organized noise-field contributors.

Of particular interest during the reporting period are the spectra for 10 August which were specially computed at 1.4 cps because of the predominance of energy at this frequency (Figure III-6). The strongest noise contributor originates north of the station and propagates with an apparent horizontal velocity of approximately 5 km/sec. The most striking feature of these spectra is the manner in which they are highly peaked as opposed to peaks in other spectra which are less well-defined, indicating probable spatial organization of this component. Previous spatial prediction filtering results have shown this energy to be organized. Thus far, tests to determine the exact cause of the 1.4-cps contributor have been inconclusive. It has been postulated, due to the apparent dependence of peak level upon rainfall, that the cause may be the many streams and rivers north of the observatory.

## 3. Conclusions

Results presented in this section show that the ambient noise field, as described by single-channel power density spectra and frequency-wavenumber spectra, has not changed significantly from the field modeled in the previous contract year. The same major organized contributors to the field consistently appear in  $f$ - $\vec{k}$  space, and the single-channel spectral shape is remaining constant. Therefore, the filters developed previously for use in the DMCF appear to be accurate for normal noise days. As was discussed in CPO Quarterly Report No. 4\*\*, the  $f$ - $\vec{k}$  method of investigating

\* Ibid

\*\* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.



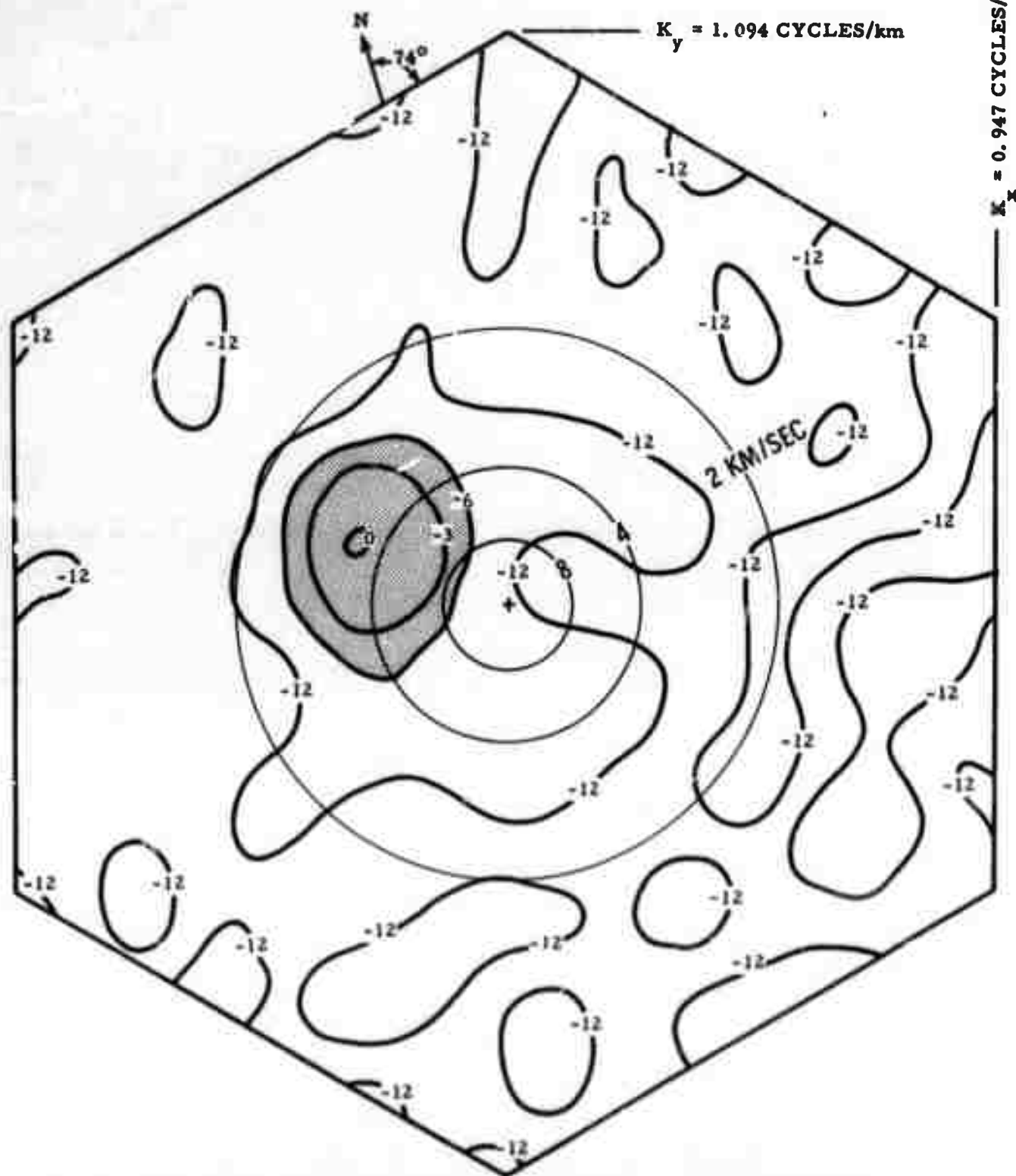


Figure III-3. CPO Ambient Noise Frequency-Wavenumber Spectrum  
5 July 1966 ( $f = 1.00 \text{ cps}$ )

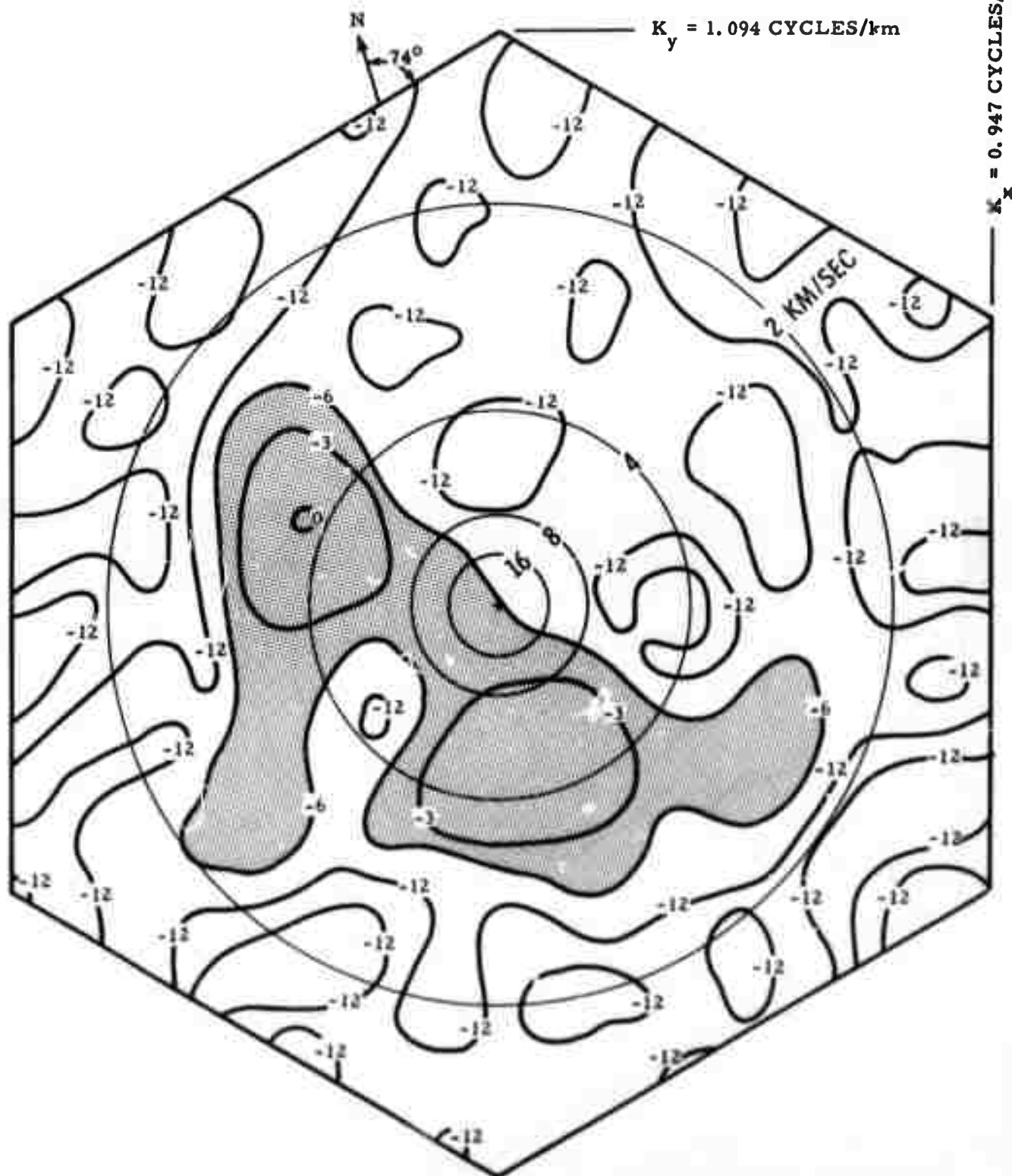


Figure III-4. CPO Ambient Noise Frequency-Wavenumber Spectrum, 5 - 1966 ( $f = 1.50 \text{ cps}$ )

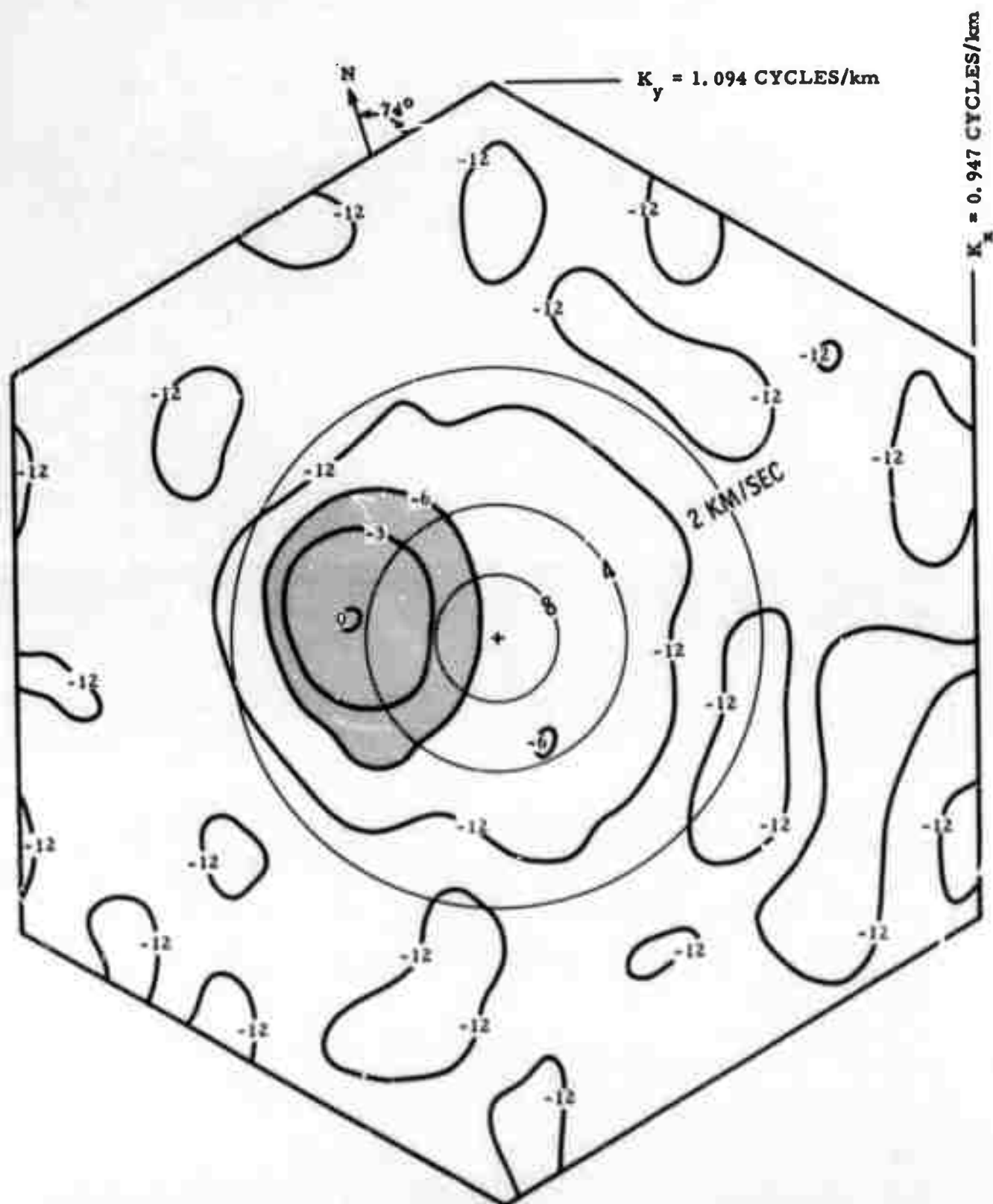


Figure III-5. CPO Ambient Noise Frequency-Wavenumber Spectrum, 18 August 1966 ( $f = 1.00$  cps)

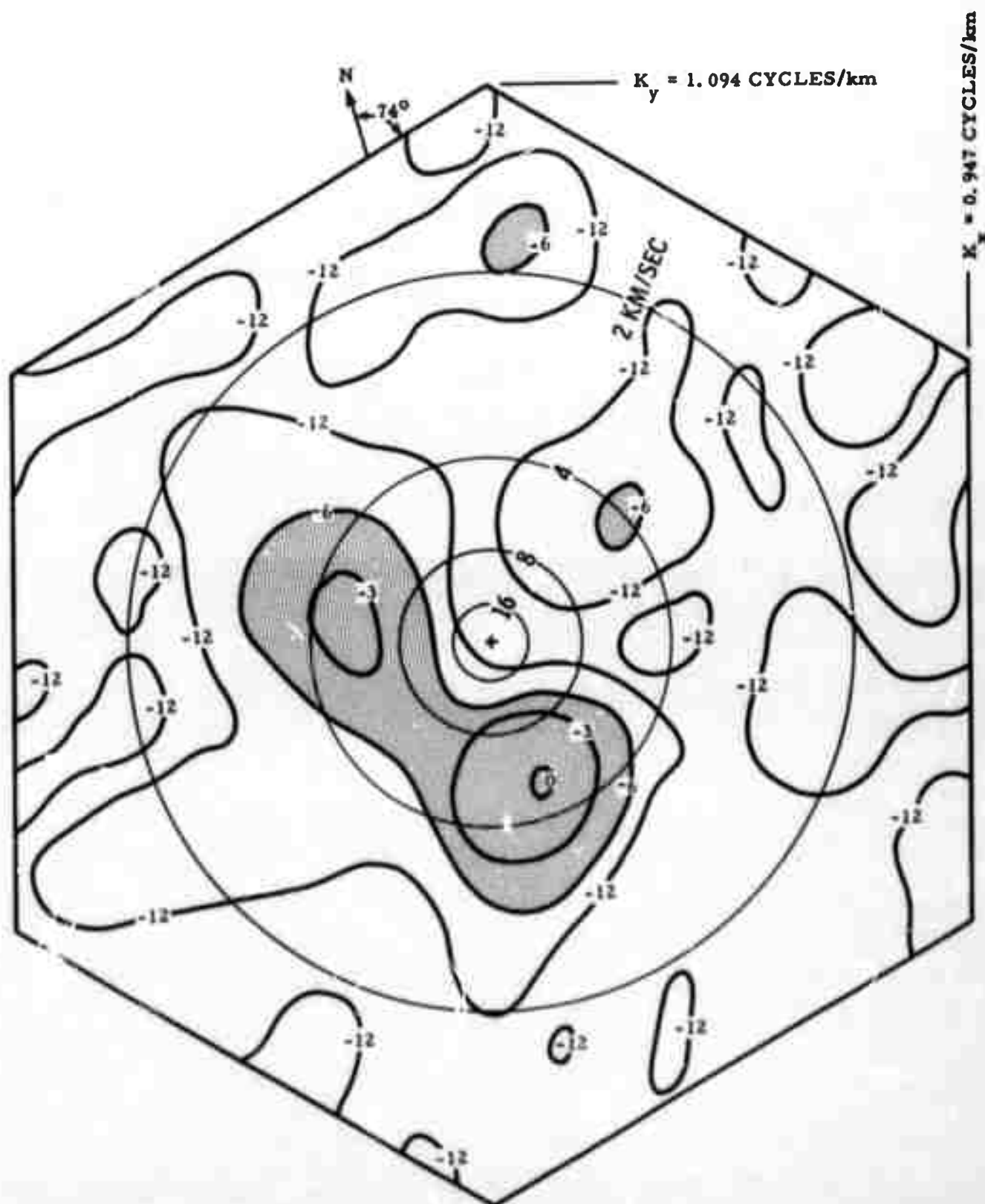


Figure III-6. CPO Ambient Noise Frequency-Wavenumber Spectrum, 18 August 1966, ( $f = 1.40 \text{ cps}$ )

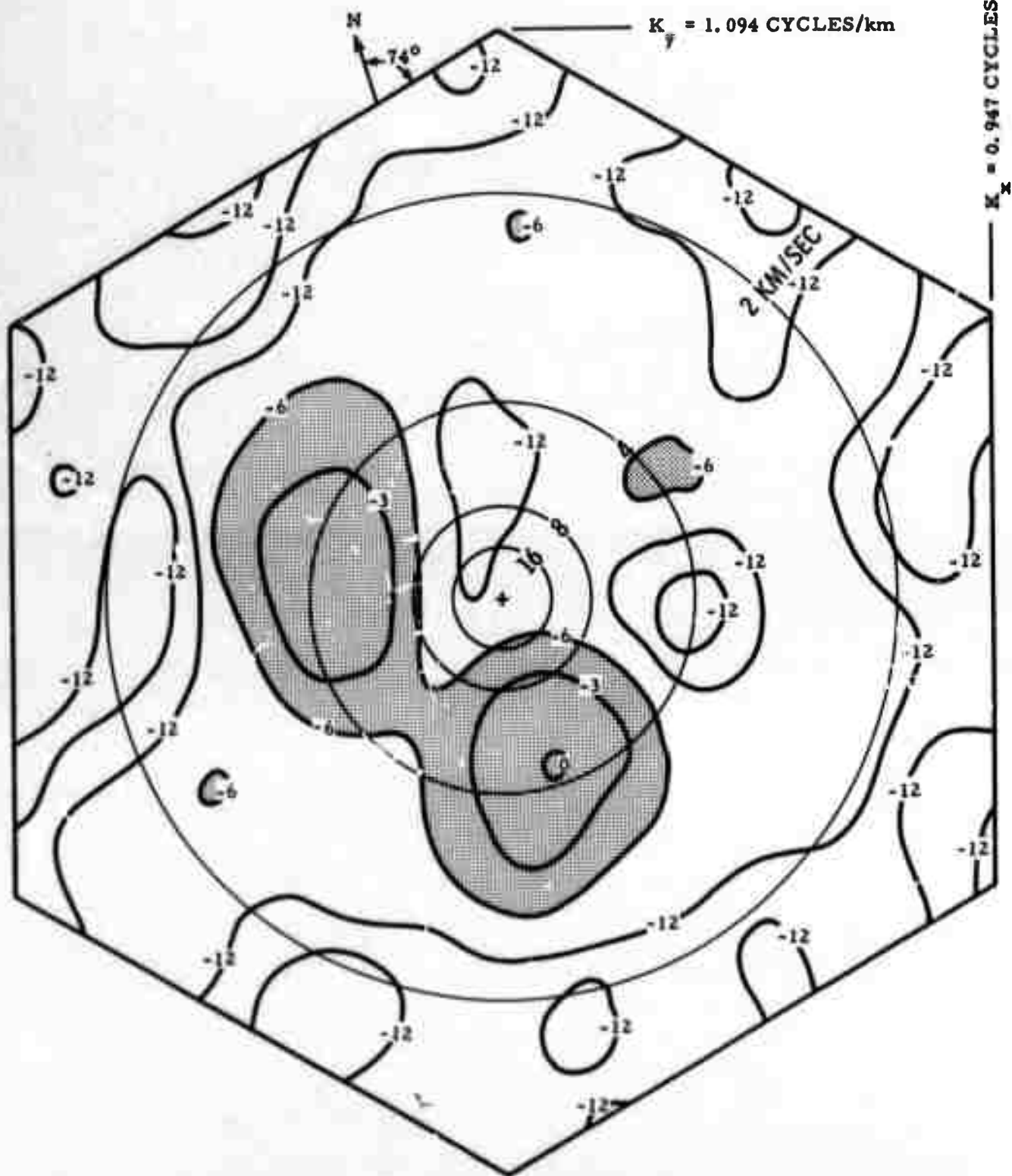


Figure III-7. CPO Ambient Noise Frequency-Wavenumber Spectrum, 18 August 1966 ( $f = 1.50 \text{ cps}$ )





noise-field properties is limited to the study of major properties due to spectral-window considerations and plane-wave assumptions.

### C. AUXILIARY PROCESSOR

#### 1. General

This task includes the design, construction, installation, and evaluation of an auxiliary processor capable of computing on-line Wiener, Fisher, and UK statistics. The unit will be interfaced with the MCF and operated on-line at CPO. Research for this task includes the development of a simulation program to verify the processor logic, to evaluate truncation errors introduced in the processor at various points, and to determine the operating parameters which will be used in the processor when it is installed on-line. Work will also include an investigation to determine the effects on the Fisher and UK processes of violations of the assumption that the ambient noise field is random. The CPO ambient noise field does not meet this condition in the frequency band of interest.

#### 2. Detection Processing Research

This task has been initially directed toward writing a simulation program of the processor. During the reporting period, the program was completed and was used to test the processor logic. This was accomplished by running test tapes through the processor and checking the output against the known test outputs. Results of this study showed that the processor logic was correct and that the processor computed the Fisher, UK and Wiener outputs as expected. Additionally, the program input-output subroutines were modified to handle real data which could be input on IBM magnetic tape.

Results of processing actual CPO data through the processor simulation program were to be published in this report; however, operational problems have delayed this processing. When these problems are solved, plans are to process several CPO events and noise samples through the program, determining the effects of each of the processing techniques on actual CPO data. These results will be used to determine the operating parameters to be used in the processor when it is installed on-line at CPO.

Data, which have been selected for processing using this program, were collected at CPO during 1963 from the 19-channel short-period array. Four samples, teleseisms AA, BB, and CC and nuclear blast AA, were chosen.\*

Basic research to determine the effect on the different processes of the coherence of the ambient noise field has not yet been completed. However, plans for this task are currently being formulated and results of this study will be discussed in CPO Quarterly Report No. 6.

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\* Texas Instruments Incorporated, 1965: Array Research Semiannual Tech. Rpt. No. 4, Contract AF 33(657)-12747, 15 Dec., p. VIII-2.



### 3. Processor Design and Construction

During this quarter, work has progressed satisfactorily on the design and construction of the auxiliary processor. On 30 September, the MCF, which is the prime unit, was taken off-line at CPO, acceptance-tested as a precautionary measure\*, and packed for shipment to the Apparatus division of Texas Instruments. The unit was shipped on 1 October and arrived in Dallas on 3 October.

As of 31 October, the end of reporting period, the following milestones had been reached on the construction of the processor:

- The DMCF had been modified to interface with the auxiliary processor and had been run through the formal acceptance test to show that it would still function as a single-unit multichannel filter system.
- Construction of the auxiliary processor and check-out of the processor had both been completed. Results showed that the hardware was in working condition and would function as expected as a single piece of equipment.
- The two processors had been interconnected and overall system checkout had begun.
- The engineering portion of the handbook was 95-percent complete
- The final copy of the acceptance test was 90-percent complete.

Also, the complete program is on schedule and is expected to meet the following deadlines:

- 1 December 1966 — Complete checkout
- 15 December 1966 — Complete acceptance tests
- 16 December 1966 — Begin preparations for shipment to CPO
- 1 January 1967 — Complete installation of the two units at CPO

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\* Texas Instruments Incorporated, 1966: CPO Special Rpt.No. 2, Contract AF 33(657)-14648, 21 Sept., Appendix B.



## D. MCF EVALUATION

### 1. Introduction

This study is directed toward determining the increased detection capability provided CPO by the MCF and is oriented toward analyst interpretation. Significant evaluation of this increase is based upon the development for each month of two lists of events — one containing events detected on the MCF outputs and the other containing events detected without the aid of the MCF. Results for the month of July 1966 were reported in CPO Quarterly Report No. 4\* and showed an increase of 195 events or 63.725 percent with the processor.

### 2. Presentation of Data

During the reported period, compilation of the two lists of events for August 1966 data was accomplished. The complete lists are shown in Appendix B. Results of this study are summarized in Table 3, which shows the daily total for both lists and the daily percentage increase in the number of events reported using the MCF. From the table, the following summary comments are made:

- Processor results showed an increase of 165 events (46 percent).
- On 9 August, the percent increase was -7 when 14 events were reported without the processor and only 13 events were reported with the processor. This relatively small number of events reported with the processor, as compared to the data without the processor, is due to the fact that the processor was off-line for several hours during the day because of an electrical storm at the station. (See subsection IIC-3 for a discussion of processor downtimes and coefficient losses.)

To point out the type of events which station personnel detected only on the MCF output, Figures III-8 through III-13 are presented. These figures demonstrate the advantage given the station personnel by the MCF outputs compared to normal station data. Station time of the P-arrivals is shown by the small arrow. The first motions of the P-arrivals on the DMCF output, which is delayed by 0.85 sec\*\*, is shown by the large arrows.

\* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.

\*\* This delay is due to the two-sided filters used in the processor. The processor delay time is shown by the second break in the last trace on the secondary records. The station time, as shown by the first break in the same trace, lines up with the time marks displayed across the record.

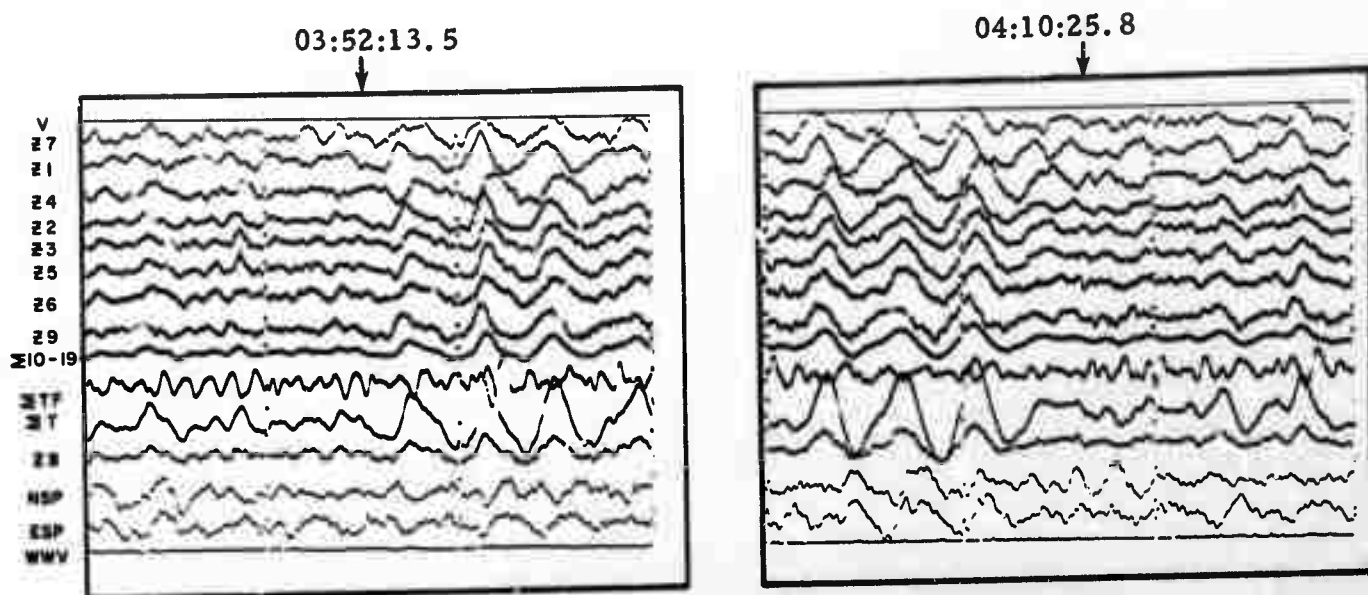




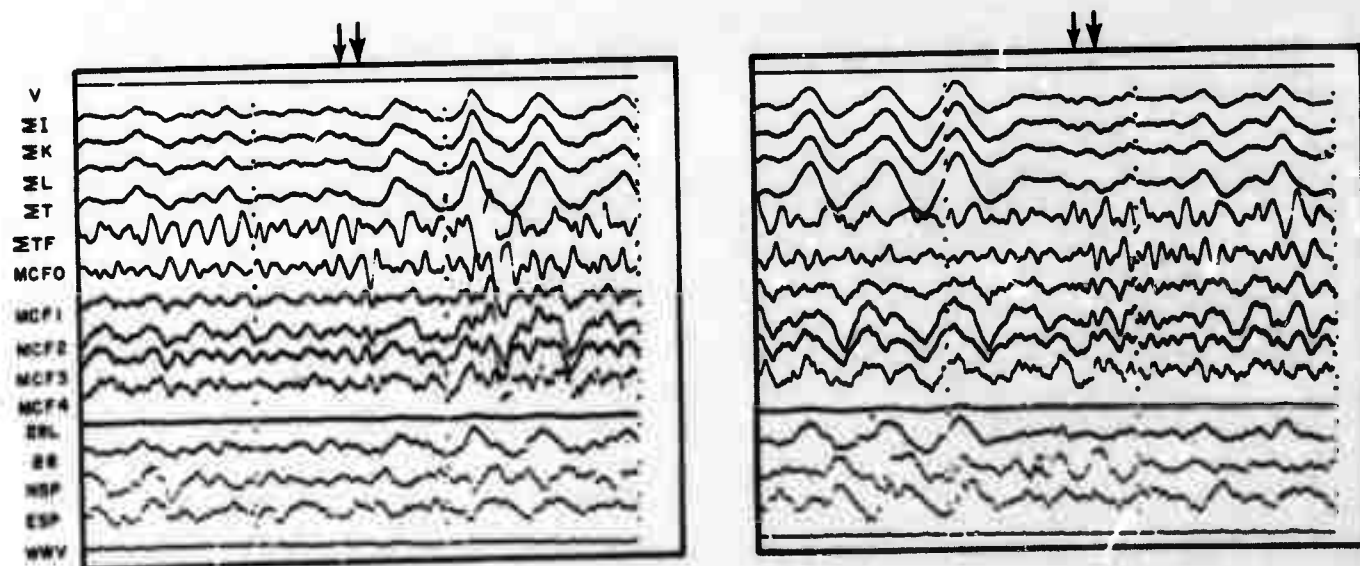
Table 3  
CPO MCF OUTPUT STUDY FOR AUGUST 1966

Date	Number of Events Reported Without MCF Data	Number of Events Reported With MCF Data	Percent Increase in Number of Reported Events With MCF
01	15	21	40
02	7	13	86
03	8	14	75
04	10	23	130
05	No Data Available	22	
06	11	22	100
07	13	17	31
08	11	19	73
09	14	13	-7
10	15	16	7
11	12	20	67
12	9	14	56
13	8	16	100
14	10	11	10
15	13	23	77
16	17	18	6
17	17	22	29
18	19	23	21
19	No Data Available	24	
20	23	28	22
21	13	17	31
22	13	24	85
23	11	14	27
24	11	17	54
25	5	9	80
26	11	19	73
27	10	15	50
28	16	25	56
29	11	19	72
30	12	14	17
31	13	17	31
TOTAL	358	523*	46

\* Total does not include result for days when no data available for column without MCF data



PRIMARY



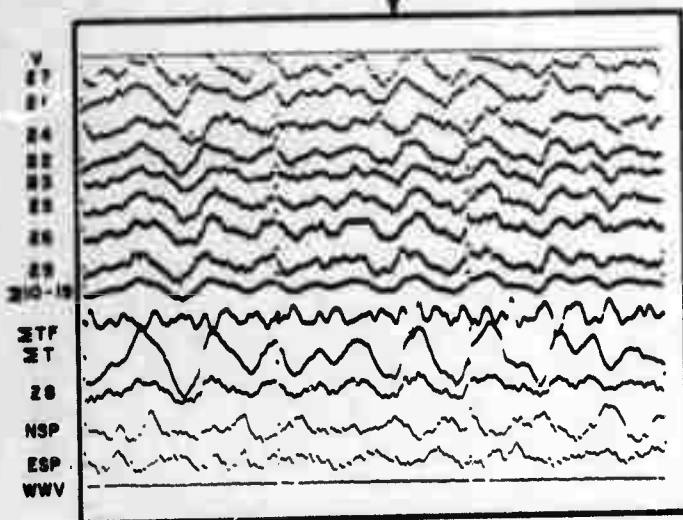
SECONDARY

AUGUST 1, 1966

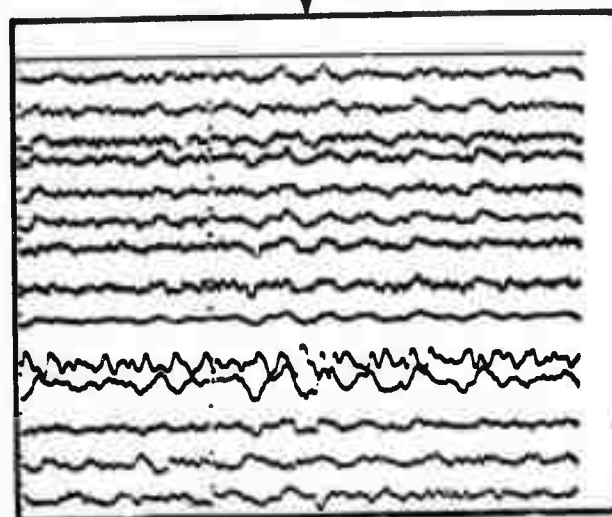
AUGUST 1, 1966

Figure III-8. CPO Primary and Secondary Develocorder Records

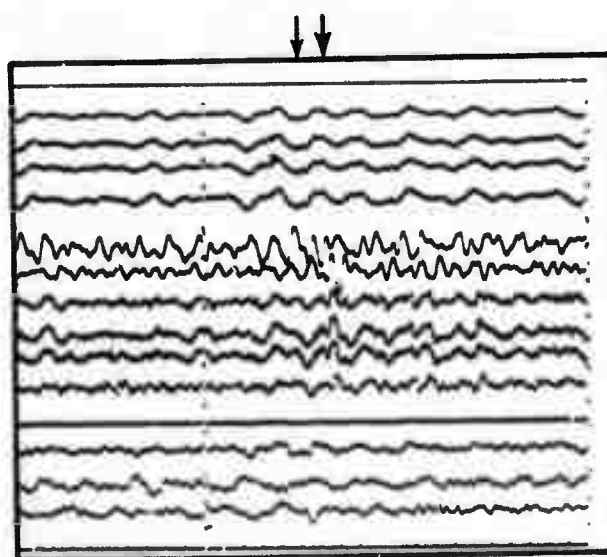
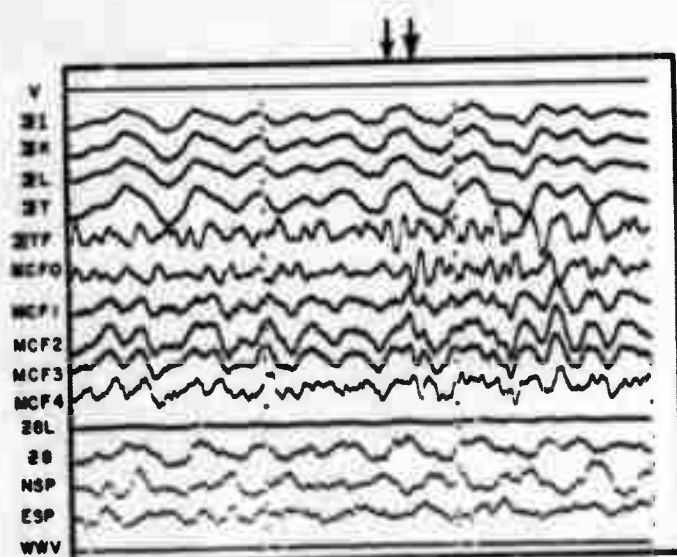
06:19:46.2



05:20:55.0



PRIMARY



## SECONDARY

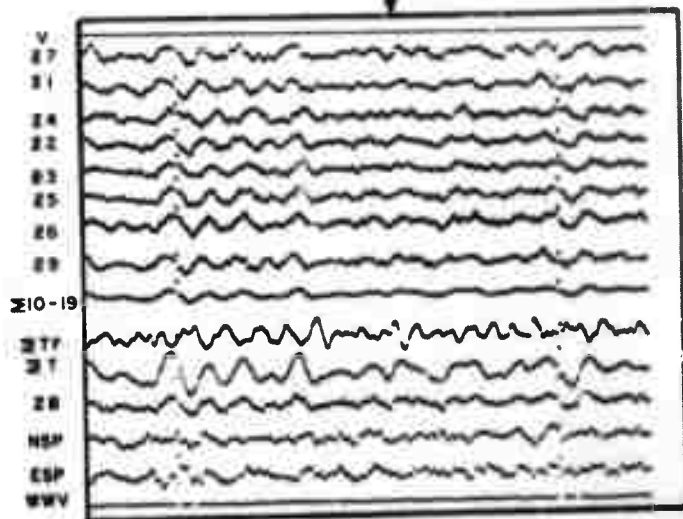
**AUGUST 1, 1966**

AUGUST 13, 1966

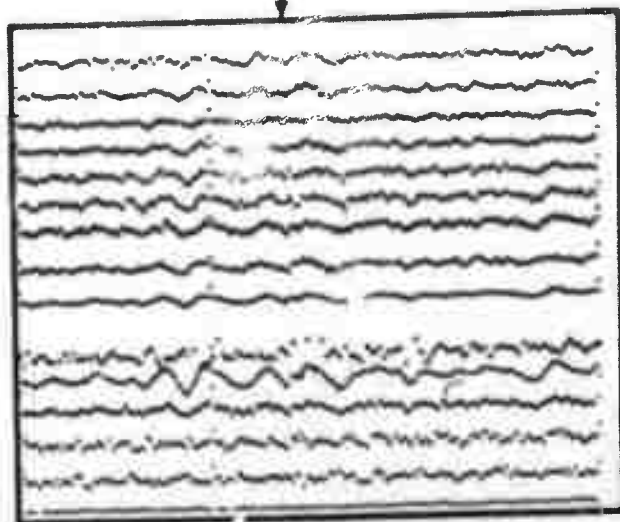
**Figure III-9. CPO Primary and Secondary Develocorder Records**



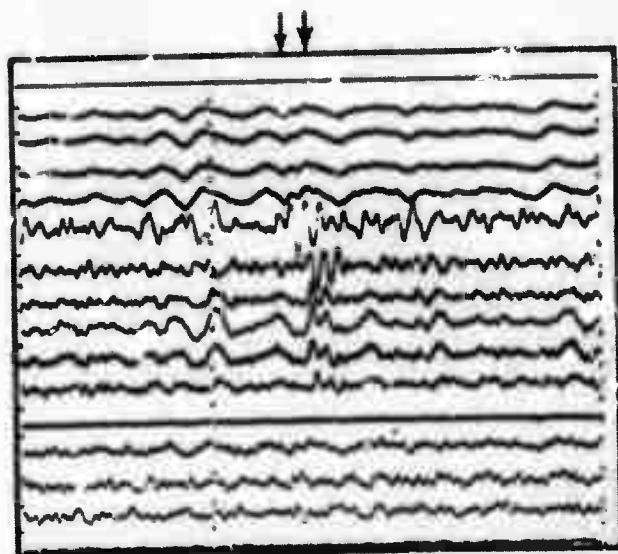
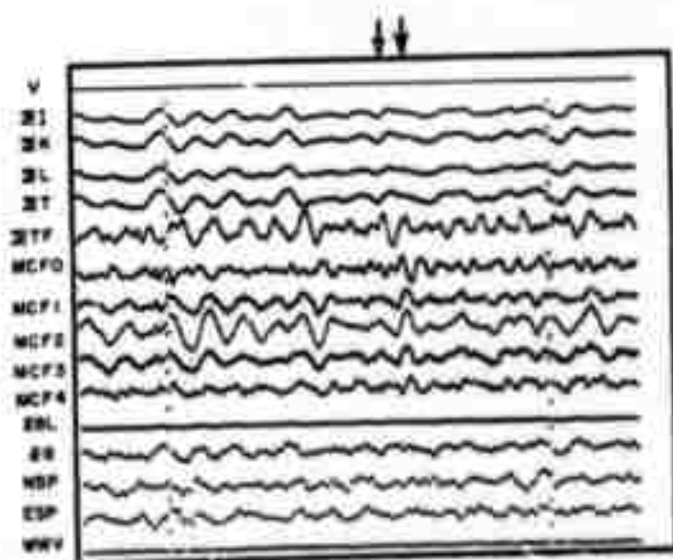
08:29:00.8



02:11:53.8



PRIMARY

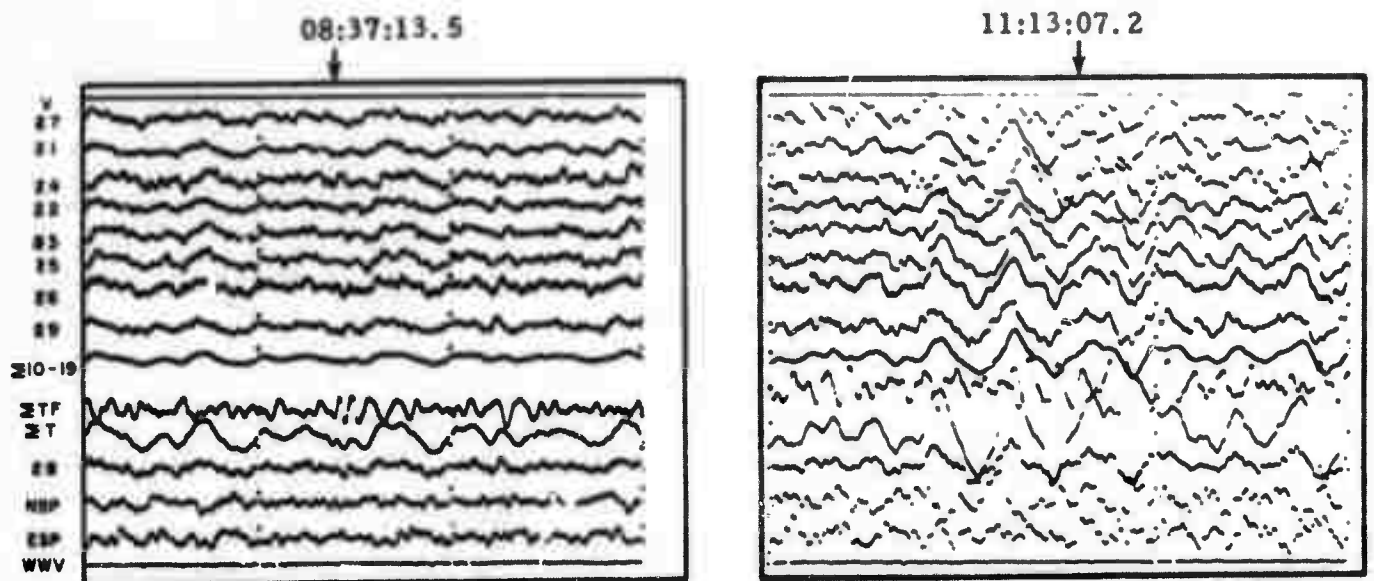


SECONDARY

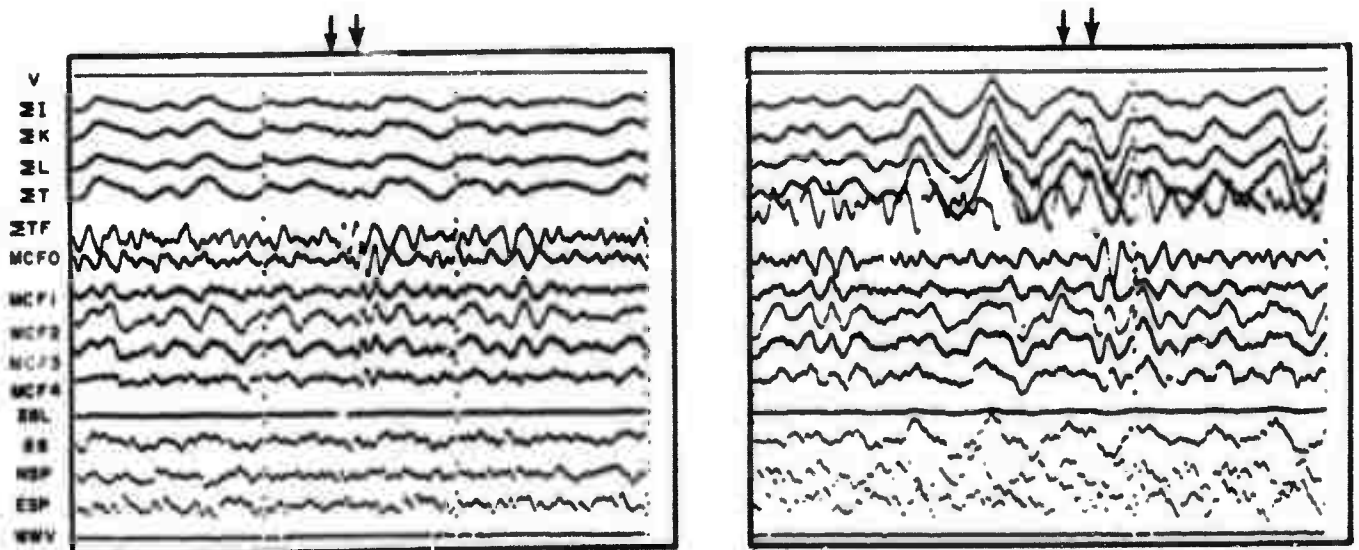
AUGUST 26, 1966

AUGUST 28, 1966

Figure III-12. CPO Primary and Secondary Developocorder Records



PRIMARY



SECONDARY

AUGUST 29, 1966      AUGUST 31, 1966  
Figure III-13. CPO Primary and Secondary Develocorder Records





### 3. Conclusions

The results mentioned in the preceding and presented in Table 3 show that there is an advantage given to station personnel through use of the processor outputs. Future plans for this study call for compiling similar lists each month when the processor is available on-line at CPO. Also, as a result of this study, other items will be investigated and evaluated including:

- The possibility of revising standard station analysis procedures to better utilize the MCF
- Determination of false alarm rates for the two lists of events
- A determination of why the number of reported events did not decrease during October 1966 as compared with previous months when MCF was operating on-line at CPO.

### E. IMPROVEMENT OF VISUAL DATA DISPLAY

The purpose of this task is to improve visual Develocorder data displays in order to aid station analysts in interpretation of event arrivals. At present, two approaches to this task are being studied; the first of these is the development of single-channel filters which will be applied on-line in the MCF to remove system amplitude and velocity responses. The second effort is a study of several variable display techniques. Included will be both variable area playbacks and bandpass filtering of recorded events to determine which type of system is best.

#### 1. Single-Channel Filtering Technique

In this task, the visual data display is improved by removing the system amplitude and velocity responses using single-channel filters which will be applied on-line at CPO using the MCF. Removal will be accomplished over various frequency bands. The rejection of the predominant 4 to 6 second-period microseismic energy will be particularly necessary.

To accomplish this task, station personnel calibrated the Z1 to Z10 seismometers twice daily for 1-1/2 months at the frequencies of 0.25, 0.50, 0.75, 1.00, 1.50, 2.00, and 3.00 cps. From these calibrations, an average response for each of the seismometers was then calculated to account for the daily variations in the responses. Since only the responses for Z1 to Z10 were available, these 10 responses were averaged to yield one response which should be representative of all 19 short-period instruments. A comparison of this average measured response is shown in Figure III-14 and is compared with the vendor's published response.

From the amplitude response, a system velocity response was obtained by scaling the amplitude response by the factor  $2\pi f$ , where

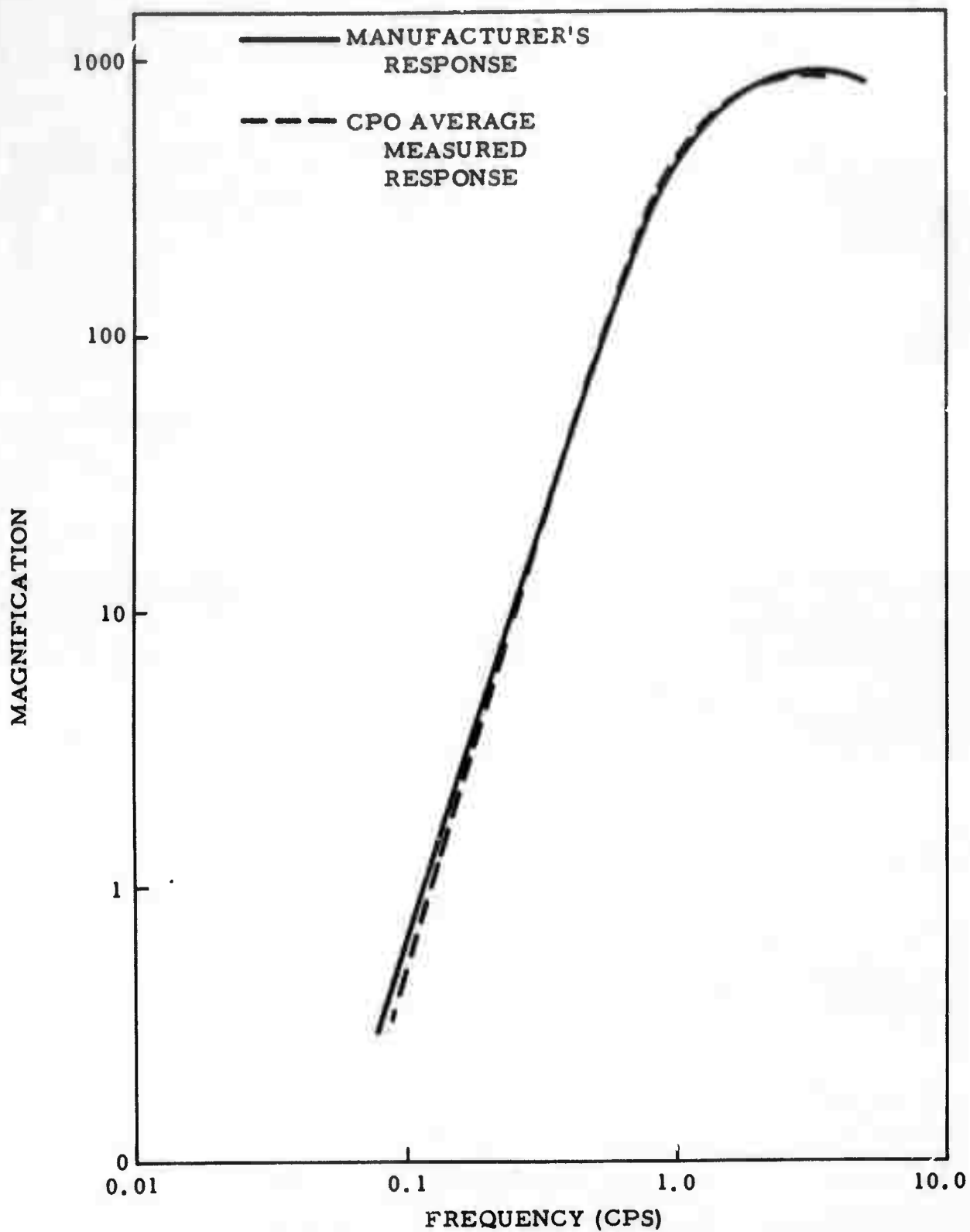


Figure III-14. Comparison of JM SP Responses



$f$  is the frequency. To obtain the response of the filters which would remove the amplitude and velocity responses, reciprocals of these responses were calculated and are displayed in Figure III-15.

As of 31 October, several unsuccessful attempts had been made to design the two single-channel filters. A weighted mean-square-error technique was used which weights the importance of duplicating the desired response shape over specified frequency bands. This technique, although effective in providing an optimum filter response, does require some experimentation with weighting factors to determine a suitable combination.

It is planned to complete the development of these filters with a specified passband of 0.3 to 3.0 cps, and then evaluate the improvement to visual analysis of CPO data using filtered signal and noise data. Results of the evaluation would suggest variations to this approach which should be tried.

## 2. Variable Display Technique

Several different playback techniques have been analyzed in conjunction with improving visual display of data to determine which technique or combination of techniques is best to aid station analysts in picking event arrival times and event first-motion directions and identifying event phases.

Early results in this task have shown that a good aid technique in the identification of first arrivals and phase detection is a combination of variable area playbacks with wiggly traces and bandpass filtering (0.8 to 1.8 cps). Figure III-16 shows a small earthquake recorded at CPO on 9 May 1963 from the Pacific Ocean at an approximate distance of 40 degrees. "A" shows the event as recorded at CPO, "B" shows the variable area wiggly trace playback of the event and "C" shows the same data as "B", except the event has been filtered by a bandpass filter with a 0.8 to 1.8 cps passband.

This figure clearly shows the advantage of this method in the analysis and reporting of small earthquakes. Number 1 shows the first arrivals of the event, while 2, 3 and 4 point out later phases of the event. Of special interest in this figure is the way that phase 4 stands out from the background in parts "B" and "C" as compared to part "A", where it would probably not be identified.

Further analysis of other events is to be performed during the next quarter and will be discussed in a special report. Also, other similar techniques will be investigated.



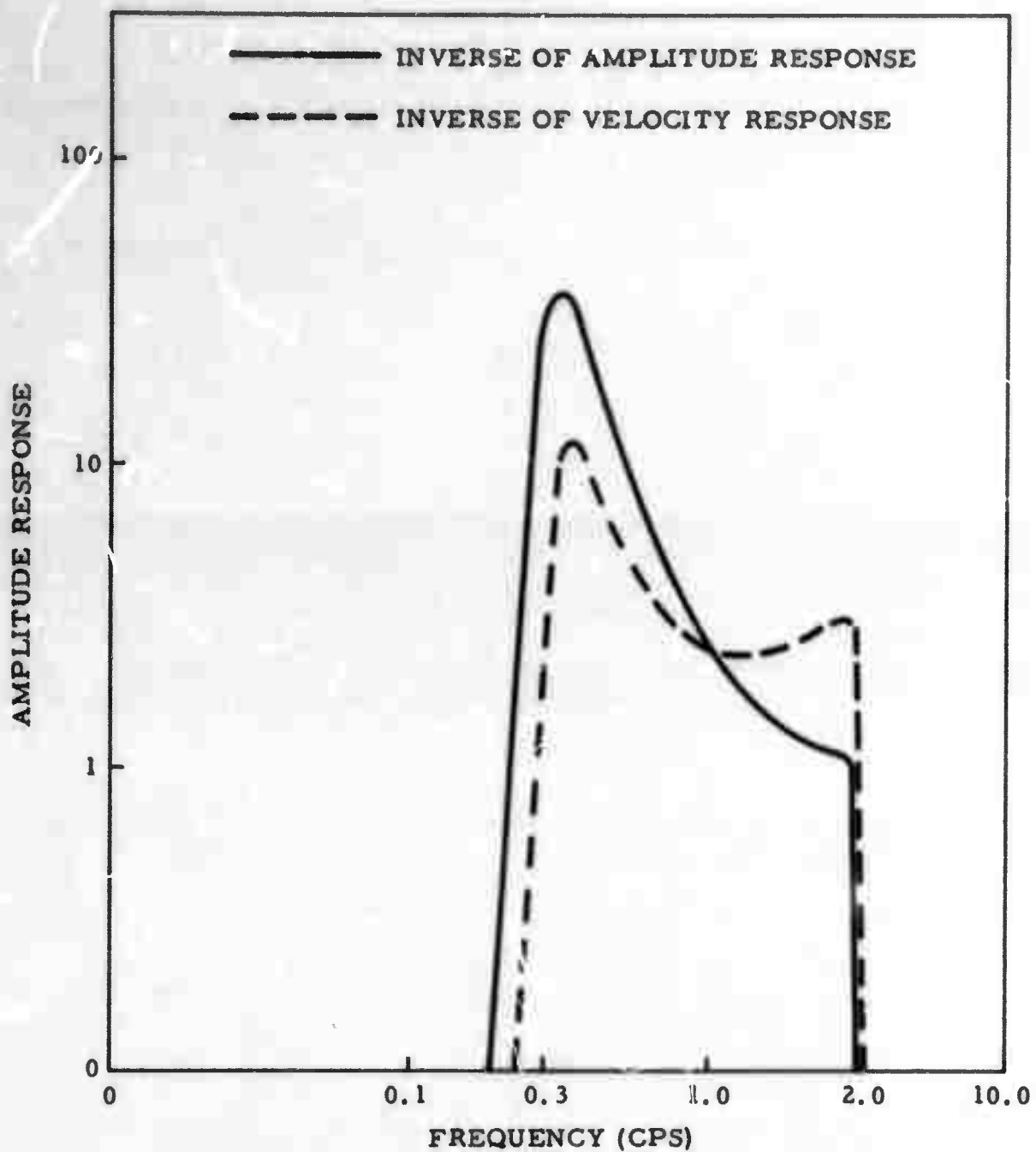
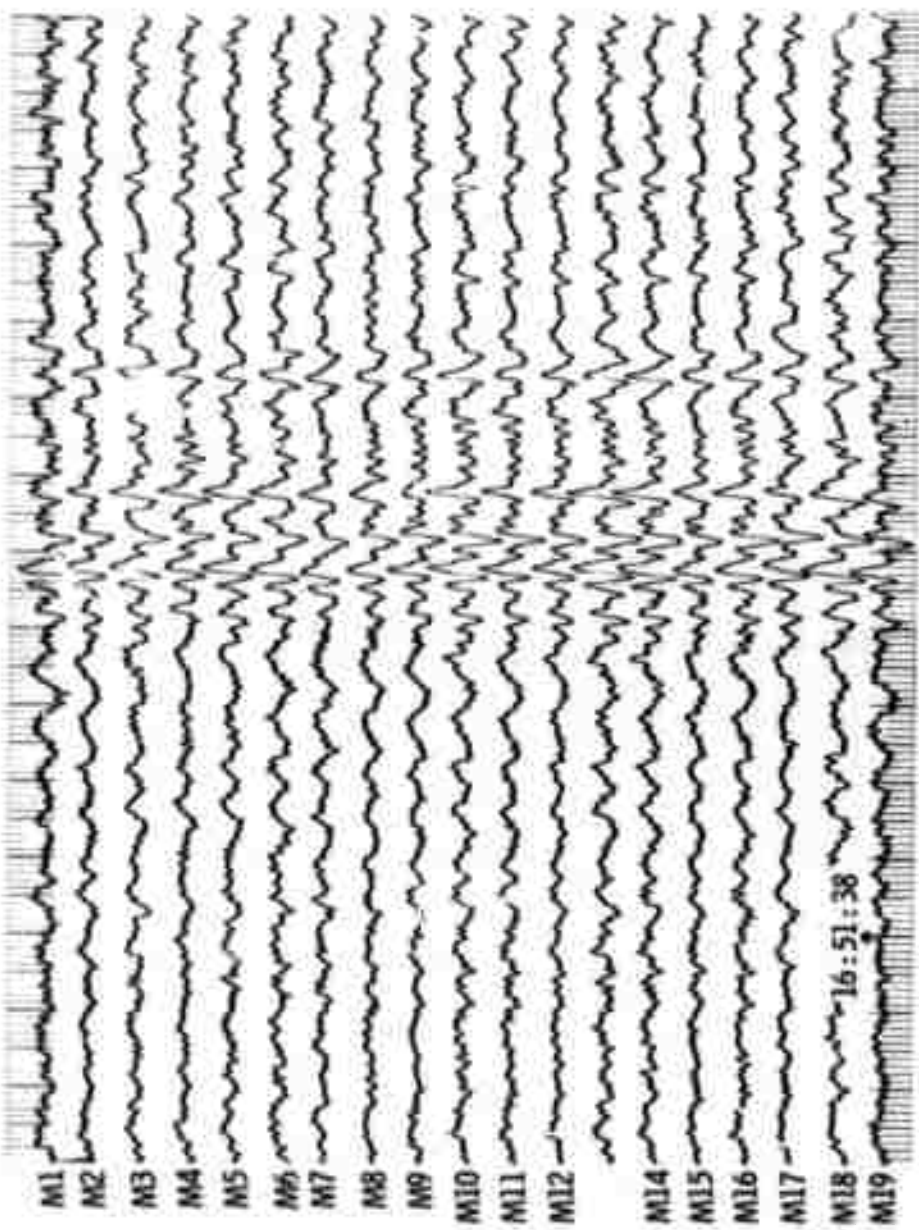


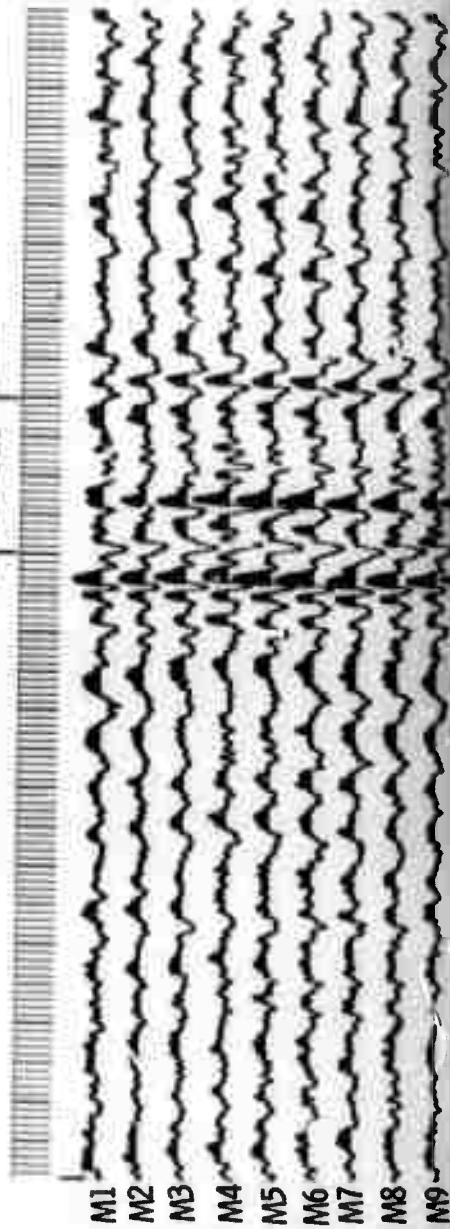
Figure III-15. Inverse of Amplitude and Velocity Response over Desired Passband

A

A



7.2 SEC



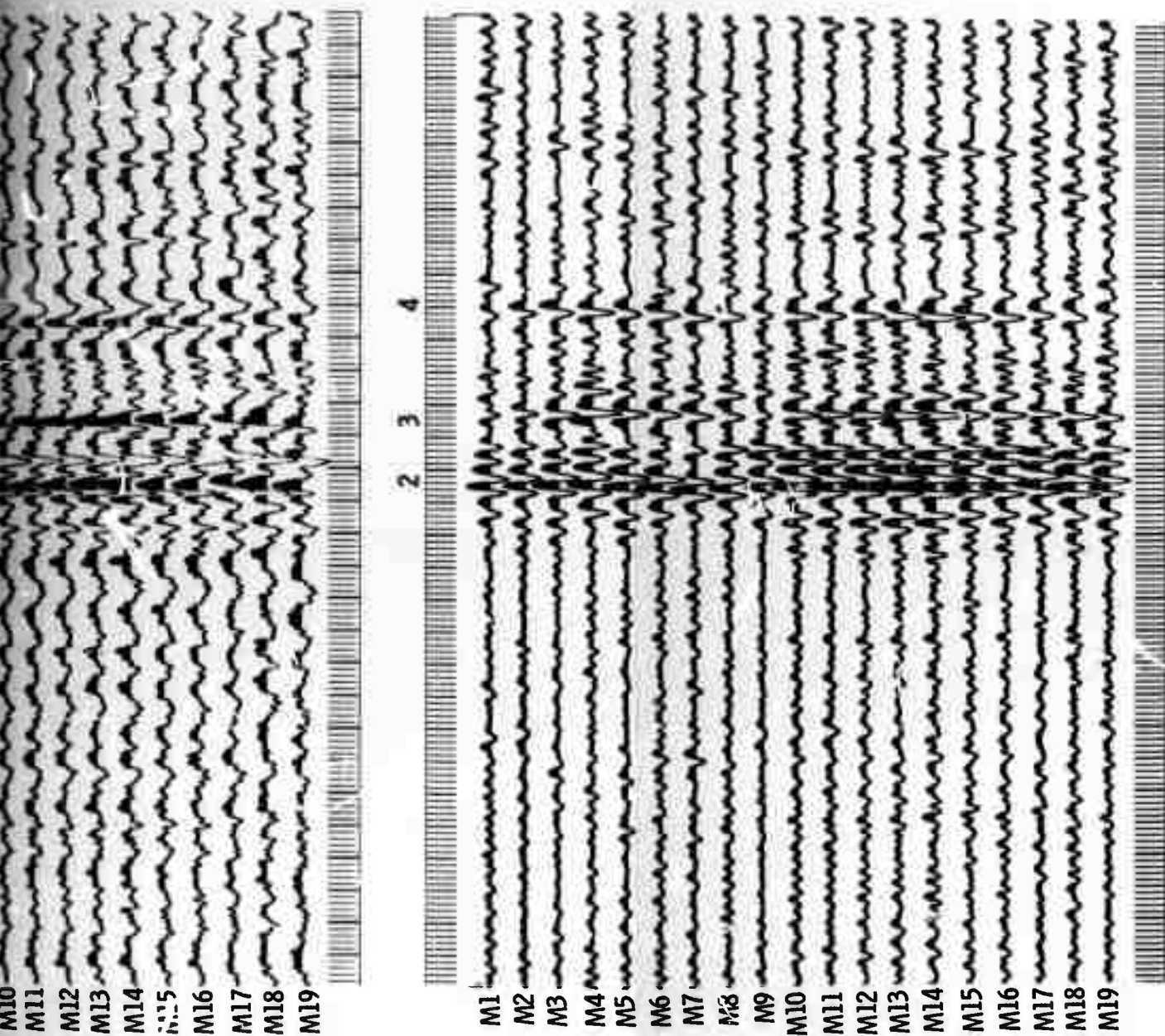


Figure III-16. CPO Event 9, May 1963: (A) Straight Playback; (B) Variable Area, Wiggly Trace; (C) Variable Area, Wiggly Trace, Passband Filtered 0.8 - 1.8 cps



**APPENDIX A**  
**COEFFICIENT LOSS PROBLEM**

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## APPENDIX A

### COEFFICIENT LOSS PROBLEM

Presented in this appendix are the details of the coefficient loss problem which have been experienced at CPO with the MCF since installation. As discussed in Section IIC-3, a probable cause of this loss problem has been identified and a suitable modification incorporated into the MCF to avoid further losses.

#### A. PROBLEM HISTORY

Available data concerning coefficient losses which has been routinely collected in the observatory MCF operation and maintenance log is outlined in Table A-1. Analysis of this data yields the following conclusions:

- Coefficient losses are associated with local electrical storms
- The losses occur randomly among input channels, output channels and filter points
- Coefficient losses are characterized by failure to complete a read/write cycle for the coefficient

The initial processor problems were characterized not only by coefficient losses, but also by entire memory losses (i.e., the entire memory would contain zero coefficients). During May the memory loss problem was corrected and the processor restored to good operating condition which at that time was thought sufficient to correct the coefficient loss problem. The following excerpts from a standard TI maintenance report describe the problems encountered up to May and the corrective action taken at that time:

"Memory losses were caused by two problems. One was several damaged components in both the memory subsystem and in the processor logic power supply, and the other problem was some bad solder joints on a printed circuit card in the memory. The directness in locating these problems was hampered because memory loss did not always occur for the same set of applied conditions and because of a few peripheral problems which clouded the analysis.

"The bad components were mostly located in power supply sections of the equipment. Rectifier CR8 in the memory power supply was knocked out at 18:04 GMT on 8 April, and diodes CR1 and CR2 and transistor





Table A-1  
COEFFICIENT LOSS DATA

<u>Date</u>	<u>Time</u>	<u>Location</u>			<u>Filter Point</u>	<u>Coeff After Loss</u>	<u>Conditions</u>
		<u>Output Chan</u>	<u>Input Chan</u>	<u>Point</u>			
4-8-66	2342	2	19	25	0000	0000	Lightning
		3	12	24	0000	0000	Lightning
4-12-66	Overnight	0	12	00	0000	0000	Lightning
		0	12	01	0000	0000	Lightning
		0	12	02	0000	0000	Lightning
		0	13	04	0000	0000	Lightning
		0	13	05	0000	0000	Lightning
		0	13	06	0000	0000	Lightning
		0	13	07	0000	0000	Lightning
		0	13	09	0000	0000	Lightning
		1	11	02	0000	0000	Lightning
		1	11	06	0400	0000	Lightning
		1	11	08	0000	0000	Lightning
		1	11	10	0000	0000	Lightning
		2	10	50	0000	0000	Lightning
		2	10	01	0000	0000	Lightning
		2	10	02	0000	0000	Lightning
		2	10	03	0000	0000	Lightning
		2	10	04	0000	0000	Lightning
		2	10	05	0000	0000	Lightning
		2	10	06	0000	0000	Lightning
		2	10	07	0000	0000	Lightning
		2	10	09	3413	0000	Lightning
		3	16	70	0000	0000	Lightning
		3	16	71	0000	0000	Lightning
		3	16	72	0000	0000	Lightning
		3	16	73	0000	0000	Lightning





Table A-1 (Contd)

<u>Date</u>	<u>Time</u>	<u>Location</u>			<u>Coef. After Loss</u>	<u>Conditions</u>
		<u>Output Chan</u>	<u>Input Chan</u>	<u>Filter Point</u>		
4-14-66	1621	3	16	74	0000	Power Failure
	2315	3	16	75	0000	
4-14-66	2315	3	16	76	0000	Power Failure
		3	16	77	0000	
4-16-66	2202	3	16	78	0000	Power Failure
	Overnight	4	13	00	0000	
4-18-66	Overnight	4	13	01	0000	Power Failure
		4	13	02	0000	
4-26-66	1452	4	13	03	0000	Power Failure
	2007	4	13	04	0000	
5-22-66	1518	4	13	05	0000	Power Failure
		4	13	06	0000	
4-14-66	1621	4	13	07	0000	Power Failure
	2315	4	13	08	0000	
4-16-66	2202	4	13	09	0000	Power Failure
	Overnight	0	13	78	0000	
4-18-66	Overnight	0	16	00	0000	Power Failure
		0	16	66	0000	
4-26-66	1452	0	16	68	0000	Power Failure
	2007	1	04	16	0000	
5-22-66	1518	0	U	U	U	Power Failure
		1	U	U	U	
4-26-66	1452	2	U	U	U	Power Failure
	2007	3	U	U	U	
5-22-66	1518	U	U	U	U	Power Failure
		U	U	U	U	
4-26-66	1452	0	U	U	U	Power Failure
	2007	0	U	U	U	
5-22-66	1518	3	U	U	U	Power Failure
		3	U	U	U	



Table A-1 (Contd)

Date	Time	Output Chan	Location		Coeff After Loss	Conditions
			Input Chan	Filter Point		
5-26-66	1600	4	U	U	U	
		0	16	78	L	Lightning
		1	16	05	L	
5-27-66	1448	0	18	78	L	Lightning
6-17-66	1459	1	05	19	0000	Lightning
6-30-66	2211	0	01	05	L	Lightning
		0	02	15	L	
		1	04	36	L	
		1	10	33	L	
7-1-66	1500	1	05	27	L	Lightning
7-2-66	2306	0	13	28	L	Lightning
		1	06	12	L	
7-3-66	Overnight	3	01	33	L	Lightning
7-6-66	0244	0	08	33	L	Lightning
7-7-66	1448	0	01	13	L	Lightning
		0	11	13	0000	
		0	14	24	0000	
		1	05	20	0000	
		2	03	20	0000	
		2	16	09	G	
		4	03	21	G	
7-16-66	2014	0	01	08	G	Lightning
		0	00	08	L	
		0	13	38	L	
		0	18	78	L	
		1	00	08	L	
		2	16	27	L	
		2	18	07	L	
		2	18	14	L	



Table A-1 (Contd)

Date	Time	Location			Coeff After Loss	Conditions
		Output Chan	Input Chan	Filter Point		
8-3-66	2009	0	00	00	L	Lightning
		3	06	52	0000	
		3	06	59	0000	
		3	11	67	0000	
		3	13	69	0000	
8-9-66	2054	1	07	17	0000	Lightning
		0	06	15	0000	
		0	07	06	0000	
		0	10	27	0000	
		0	10	54	0000	
		0	11	73	0000	
		0	17	18	0000	
		1	07	09	0000	
		1	18	26	0000	
		2	00	15	0000	
		2	17	18	G	
		4	00	14	L	
		4	02	37	0000	
8-12-66	1600	4	05	18	0000	Lightning
		4	00	00	0000	
		0	07	23	L	
		0	13	.8	0000	
		0	13	19	G	
8-14-66	2303	1	13	18	0000	Lightning
		3	07	23	0000	
		0	08	30	0000	
		2	08	28	0000	



Table A-1 (Contd)

Date	Time	Location			Filter Point	Coeff After Loss	Conditions
		Output Chan	Input Chan				
8-17-66	1606	3	08		27	0000	Lightning
		0	00		00	0000	
		0	08		35	0000	
		C	18		35	0000	
		1	06		25	0000	
		2	07		34	0000	
		2	17		05	L	
8-20-66	2143	0	00		00	0000	Lightning
		0	00		26	0000	
		0	02		57	0000	
		1	10		29	0000	
		1	11		60	G	
		2	00		00	L	
		2	04		32	0000	
		2	07		33	0000	
		2	10		29	G	
		3	12		17	0000	
		4	00		00	G	
		1	11		06	G	
		0	18		78	0000	
9-14-66	2204	C	10		45	0000	U
9-19-66	1556	0	00		00	0000	U
		0	00		02	0000	Lightning
		0	00		04	0000	
		0	05		06	0000	
		0	07		05	0000	
		0	18		78	0000	
		1	00		00	0000	
		.	00		01	0000	



Table A-1 (Contd)

<u>Date</u>	<u>Time</u>	<u>Location</u>		<u>Filter</u>	<u>Coef After</u>		<u>Conditions</u>
		<u>Output</u>	<u>Input</u>		<u>Loss</u>		
		<u>Chan</u>	<u>Chan</u>	<u>Point</u>			
		2	00	00		0000	
		2	04	33		0000	
		3	00	09		0000	
		4	00	00		0000	
		4	00	10		0000	

U - Unknown  
L - Lost Bit  
G - Gained Bit



Q1 on the data-saver card and transistor Q3 of board B24 and Q1 of board B26 were found to be bad after the processor stopped working at 00:58 GMT on 29 April. The station log shows thunderstorms with lightning in the area on both of these occasions. Station personnel replaced these components, but random memory losses still occurred and assistance was requested.

The remainder of the problem was traced to two damaged 8000  $\mu$ f electrolytic filter capacitors in the processor logic power supply and seven bad solder joints on board B22 in the memory. One of the capacitors had its vent blown open, and indications are that they were damaged at the same time as the previously noted components. They are located ahead of the regulators in the Dressen-Barnes 50 amp 4 v supply. The regulators were able to supply a smooth output despite the reduced effectiveness of the filter capacitors. Memory losses occurred from this problem because the reduced stored energy in the capacitors of this supply at power turn-off or failure allowed the 25 amp load on this supply to drain it to a low voltage before the data-saver circuit in the memory reacted. Thus, inadequate commands were sometimes received by the memory before the data-save cycle and memory information were destroyed. No replacement capacitors were available at the site nor in Nashville, so a special fix circuit was devised in the interim. Dressen-Barnes, Inc., the supply manufacturer, was contacted, and replacement capacitors were to be sent directly to CPO under the supply's 1-yr parts warranty. The fix circuit was a one transistor amplifier which detects an abnormally low voltage drop across the supply's series regulator transistors and initiates a stop state in the processor. Normal automatic clear-start occurs on power restoration if the "autostart" button is set. The circuit, although intended as temporary, could act as a redundant data saver when the capacitors are replaced in the logic power supply. If it is left in, improvements could probably be made in its operation by a more thorough design.

"The bad solder joints were the cause of the system losing coefficients under quiescent operating conditions. Seven joints on board B22, although appearing good even under moderate magnification, allowed the pin to move up and down through the solder pool when the board was flexed. The cause of the poor joints was apparently inadequate tinning of the leads on relatively heavy potted delay line modules prior to the flow soldering process. The joints were good but possibly weak when the unit was in Dallas and probably failed during transport of the system over the rough roads to the site. Fabritek certifies their units to a "standard commercial" 10 g vibration and a 15 g shock specification. Resoldering these seven joints cured the quiescent operating core loss occurrences.



"The other lesser things which masked the above problems and lengthened the troubleshooting time included occasional electrical noise generated by the line-printer ink-ribbon reversing mechanism, an intermittent ground connection in the molded power cord of the paper tape spooler, low contact pressure on one Elco connector in the memory, and noise generated by the memory power switch when it was used to test the data saver. The printer-ribbon-reverse noise caused an occasional print action in the printer during the long printer-enabled conditions imposed by troubleshooting. The noise was reduced by inserting capacitors across the magnetic clutch coils inside the printer. The intermittent power cord ground created transient noise in the paper tape reader logic due to a power-line filter circuit which utilizes that ground line. A replacement cord was installed. Increasing the contact pressure on the one Elco connector permitted the memory to tolerate quite severe card rattling without malfunction. Rattling of cards in the processor was likewise tried without upsetting system operation. The power switch on the memory power supply occasionally created noise on turn off-on, probably due to contact bounce. Usually 20-30 off-on cycles in a test period were required to get a malfunction during memory self-test. Decoupling capacitors were placed both across the switch and the power transformer primary to reduce the noise when it occurred. This upped the test cycles required to cause a loss in self test to 50 to 80 as indicated by about six tests of that many cycles each. It should be noted that this is not a switch used during normal system operation and is covered by an access panel. After the two main problems were corrected, the entire system was tested twice with over 100 power on-off cycles initiated with either the main system switch or external power interruption without a memory loss.

"Additionally, Fabritek readjusted the schmoo pattern on the memory as a normal requirement after the unit has been in operation after the initial several hundred hours. Two transistors were also replaced on inhibit driver cards which had degraded somewhat and reduced the memory drive margins from  $\pm 10$  percent to  $\pm 5$  percent. This degradation was apparently random component aging but did not affect the system operation. Procedures are given in the handbook to locate such gradual reductions of system operating margins and may be used as a form of preventive maintenance, if desired. Fabritek also replaced the data saver board in the memory because some etch was lifted in the replacement of components damaged on 29 April by use of too large a soldering iron.

"In summary, the system was repaired, and the major problems since installation can be attributed to several damaged components and some weak solder joints in the memory. The damaged components were mostly located in power supply sections and were likely damaged by an over-voltage condition in excess of suppression capability of the input line filter and line regulator, such as lightning could cause. Lightning arresters are installed on the power pole transformer primary."





After this maintenance and investigative effort in May, and after observing the system for one month, it was evident that the memory loss problem no longer existed but coefficient losses still occurred. Station procedures were then adopted to collect data on the loss problem and to attempt to isolate the phenomena responsible for the losses. These procedures were

- Run an hourly all-channel step-test while the station is manned
- Display the input power variations on the fourth Develocorder
- Cause the MCF to compute an all-channel step-test whenever it cycled through "stop"
- Time permitting, spot check internal voltages on a rotating-continuous schedule for unusual conditions
- Conduct additional pertinent testing as necessary

Little additional information had been gained in July other than that there was a definite correlation of loss with local electrical storms. It was hypothesized that short-duration transients during these storms could be propagating through portions of the station and causing losses through an electrical ground loop. To avoid this possibility, the following electrical ground changes were made:

- The MCF input power source was changed to run off the instrumentation source so that the PTA's, Develocorders and FM tape systems, (which have direct electrical connection with the MCF) shared a common MCF ground. Because of available station power circuitry, the MCF originally used the utilities system for input power (i.e., secondary line supplying the observatory lighting, heating, cooling, etc.).
- The electrical grounding system internal to the MCF was modified so that all sub-systems utilized a common external ground



After correcting for known ground loop problems which could exist, the sporadic coefficient loss still occurred and was associated with local lightning. The station engineering personnel then attempted to create coefficient losses under controlled conditions by creating phenomena which might occur during electrical storms. The attempt had only limited success, primarily due to unavailability of special test and experimental equipment. However, it was encouraging enough to warrant more sophisticated experimentation oriented to this approach.

Dallas engineers visited CPO again in September to accomplish additional testing and investigate lightning effects. During this effort, it was discovered that coefficient losses could be consistently reproduced by causing short duration 5-msec interruptions in the MCF input power.

The interruptions were created by passing the input current through a relay in which the poles were wired together and then triggering the relay. The interruption was caused by contact bounce. Using this technique, the rate of loss was 50 percent.

Although the cause of loss was not fully understood at the time, it was believed that if the unit could be corrected to withstand these interruptions, the loss problem would be solved. It was decided to bring the MCF back to Dallas on schedule for auxiliary processor interfacing and to further investigate the available facts. This decision was related to the project officer who approved. The decision was based on:

- The wide variety of engineering talent and special test equipment available in Dallas
- The fact that coefficient losses could be reproduced under laboratory conditions

After thorough laboratory testing in Dallas, the problem cause was definitely determined and is discussed in the next subsection along with the present solution.

## B. PROBLEM SOLUTION

A circuit has been added to the +4v, 50 amp Dressen-Barnes logic power supply of the MCF which allows the processor to survive transients of a type which has been found to cause memory core losses. This problem is one of short power line transients, too brief to trip the Fabritek memory data-saver but long enough to affect the logic power supply. Such a transient could cause the logic power supply to lose regulation and create logic noise within the MCF processor controllers such that improper commands were given to the memory and data destroyed. The circuit added to the logic supply is a redundant power source monitor to the memory data-saver, either of which will also set the processor to the "stop" control mode in the event of power problems. The logic supply monitor is required to cause a "data save" for those power line disturbances which affect the processor's logic supply without directly affecting the memory subsystem.



## 1. Results

No coefficient bit loss occurrence has resulted during extensive testing of the circuit and the theory. Approximately 100 transients of the type shown to have at least a prior 50 percent chance of causing a coefficient loss were imposed on the system during the tests. The manner used to effect the data-save is to force the system to a stop mode during the disturbance and for a short time afterwards, this is the same as that used by the integral memory data-saver. The memory data-saver standard delay recommended by Fabritek is about 120 msec. The delay to automatic restart of the processor implemented in the power supply circuit during these tests was about 100 msec after regulation was restored. Power turn-on and turn-off, complete interruption, short power loss transient, and long power loss transient tests were conducted without coefficient loss. Power line over-voltage transient tests were not conducted.

A picture of the breadboard circuit installed in the CPO MCF is shown in Figure A-1, and its operation is shown in Figure A-2. The top trace shows the 115 v-ac regulated power (Sorensen Line Regulator Output) within the system. A transient power loss was created which clipped off the lower portion of the second 115 v-ac cycle shown on the left. Another trace superimposed within the 115 v-ac trace shows the output of the breadboard circuit dropping to a low state. This signal remains low for 100 msec after the unregulated d-c in the logic supply (shown by the bottom trace) has recovered and the supply is no longer in danger of losing regulation. The threat of regulation loss is measured as the d-c level of the unregulated d-c feeding the series regulators in the logic supply. The fourth trace, located in the middle of the picture, is the +4 v regulated voltage. Loss of regulation is shown by that trace during the initial drop in the unregulated voltage following the transient. Regulation was maintained during the recovery undershoot as the regulators settled, but the monitor threshold was apparently again crossed since the signal output remained down 100 msec after that time.

Figure A-3 is the schematic of the breadboard used to verify the theory of the coefficient loss fix. It consists of a Schmitt trigger, one shot, time-delay section, output stage, and temporary energy storage for operation of the circuit during severe transients. The Schmitt trigger monitors the level of the unregulated +14 v feeding the series regulators. The time-delay section delays the resetting of the stop command for approximately 100 msec after the Schmitt has reset. The one shot ensures that a minimum pulse of about 400  $\mu$ sec is supplied to the time delay circuit through the "or gate" to adequately set the 100 msec time delay. The output stage buffers the circuit and ensures that the output command does not exceed the regulated output level and couples the command output to such occurrences as output short circuits and firings of the overvoltage SCR devices. It is assumed that the overall circuit could be simplified when more is known about all the problems.

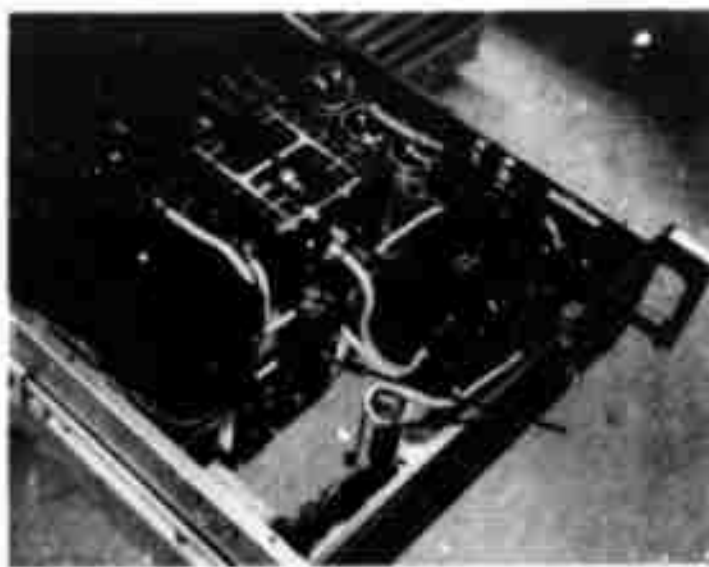
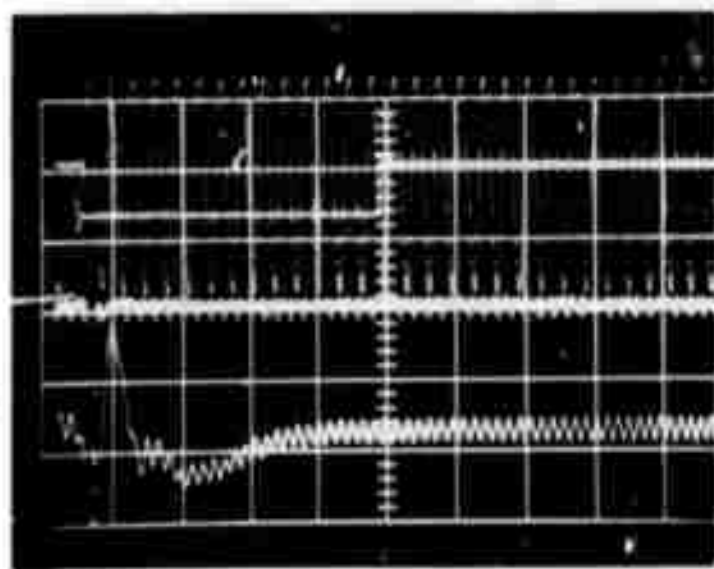


Figure A-1. Logic Power Supply with Breadboard Circuit Installed



← 115-v-ac Sorensen Output,  
100 v/cm

← +4-v Stop Command,  
Output 5 v/cm

← +4-v Regulated Voltage,  
0.5-v/cm

← +14-v Unregulated Source,  
5-v/cm

Figure A-2. Operation of the Logic Supply Monitor Circuit Breadboard







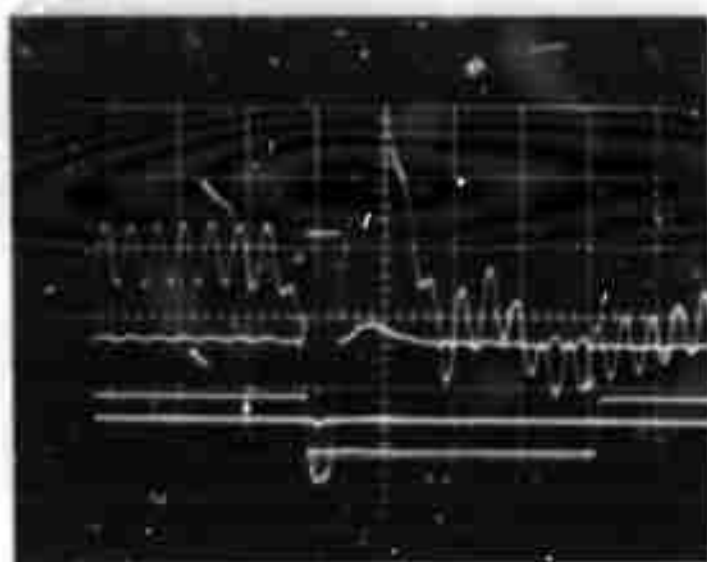
Circuit action to a marginal situation is shown in Figure A-4. The upper trace is the 14-v unregulated power to the series regulator. The energy loss, due to the transient introduced on the power line, is clearly shown. The energy reduction following the transient is from the recovery undershoot of the Sorensen regulator. The second trace shows the Schmitt trigger monitoring the unregulated level. A clean trigger action occurred at the primary transient time and the command, trace 4, is initiated. A very small notch on trace 3, and +4v regulated transient power voltage, shows the loss of regulation which occurred for the particular transient. Close inspection will show that the stop command was initiated prior to loss of regulation. The processor will react to this command within 5  $\mu$ sec. This slight disturbance of the +4v into the logic most likely would not have affected system operation, nor have caused a coefficient loss. The Schmitt trigger is designed to operate in a linear fashion as it approaches the decision points and a second trip is almost initiated by the undershoot energy loss, as can be seen by the small perturbation of the Schmitt trace at that time. Correlation of the Schmitt trace and the unregulated trace at that point is evident, but no loss of regulation occurred since the minimum level for regulation was not reached.

Figure A-5 shows the operation of the power supply monitor circuit and the memory data-saver to a more severe transient. This degree of 4-v disturbance approaches that capable of causing a bad command to the memory resulting in a coefficient loss, but notice that in this case the memory data-saver also tripped. Instances of significant 4-v disturbance without the memory data saver responding appropriately were observed but not often enough to account for the degree of coefficient losses experienced.

## 2. Conclusions

The breadboard fix installed in the MCF appears to work satisfactorily for the particular disturbance created under laboratory conditions. The full mechanism of the losses is not yet fully understood; however, future planned efforts should provide complete understanding. Plans call for:

- An attempt to simplify the fix circuit; specifically, deletion of delayed start feature will be investigated.
- Placement of the MCF on-line at CPO as soon as possible. The unit will be closely monitored to insure that further coefficient losses do not occur under field conditions.



← + 14 v Unregulated Voltage  
2-v/cm

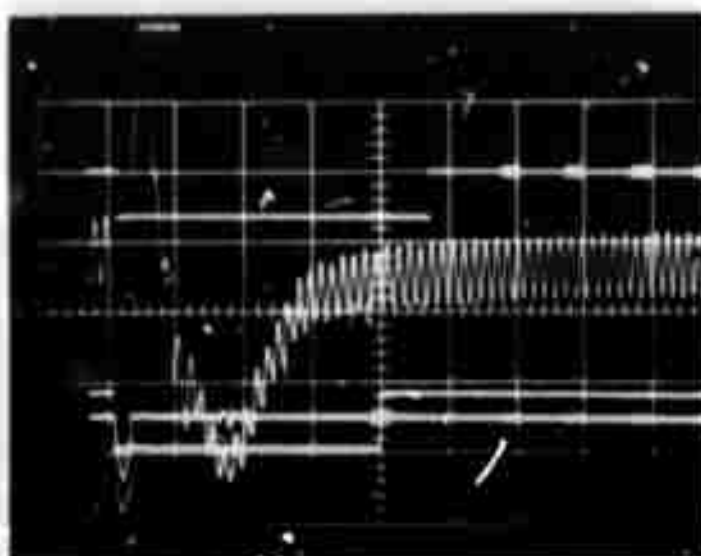
← Schmitt Trigger Monitor  
5-v/cm

← + 4-v Regulated Output  
1-v/cm

← Command Output 5-v/cm

Sweep Speed 20 msec/cm

Figure A-4. Operation of the Power Supply Monitor Circuit to Marginal Conditions



← Memory Data Saver, 5 v/cm

← + 14-v Unregulated Voltage,  
2-v/cm

← Power Supply Monitor Output  
5-v/cm

← + 4 v Regulated Output  
1-v/cm

Sweep Speed 50 msec

Figure A-5. Operation of the Power Supply Monitor Circuit to Severe Transients





### C. LOSS EFFECTS ON OUTPUT DATA

Coefficient losses in the MCF are undesirable and would not occur if the hardware was operating properly. It is believed that the problem is now solved. However, from an operational standpoint, a critical question which should be answered in light of MCF data usability during a loss is: "What effect does a coefficient loss have on visually displayed MCF output data?"

The answer to this question, although straightforward, is difficult to rapidly assess to any degree of accuracy on an individual case basis in the field. A summary answer to this question is

- Theoretically, the output of the affected MCF channel is incorrect if one or more coefficients are destroyed
- The extent of visual data distortion for a single channel under a loss condition may range from none to very severe depending upon the number of input channels affected, the number of coefficients lost per input channel and the value of the individual coefficients lost

As an example of loss effects on visual data, Figures A-6 through A-9 are presented. These figures represent reproduction of actual CPO secondary Develocorder data which contains the MCF outputs for before and after conditions of coefficient loss. In such a comparison, there is no definite means of stating the effect; however, the character of output data can be studied for obvious changes in frequency content or for apparent visually detectable increases or decreases in general trace level. For this approach the assumption must be made that the input character of seismic data is relatable to the output; if a change occurs in the input data over the period being considered, the effect this change has on the output data is known. This is not always the case, (e.g., on high-level noise days when a new organized component may be added to the spatial noise field) but, it is a reasonable assumption.

Analysis of the presented Develocorder records, in conjunction with data presented in Table A-1, indicates the following:

- Figure A-6  
MCF 0 lost one coefficient; MCF 1, one coefficient; and MCF 3, four coefficients. There is no apparent degradation on any of the affected channels



- **Figure A-7**

MCF 0 lost six coefficients; MCF 1, two coefficients; MCF 2, two coefficients; MCF 4, three coefficients. Results are inconclusive due to contradiction between apparent affected channels and channels with known losses.

- **Figure A-8**

MCF 0 lost four coefficients; MCF 1, one coefficient; MCF 3, one coefficient. No noticeable deterioration was present.

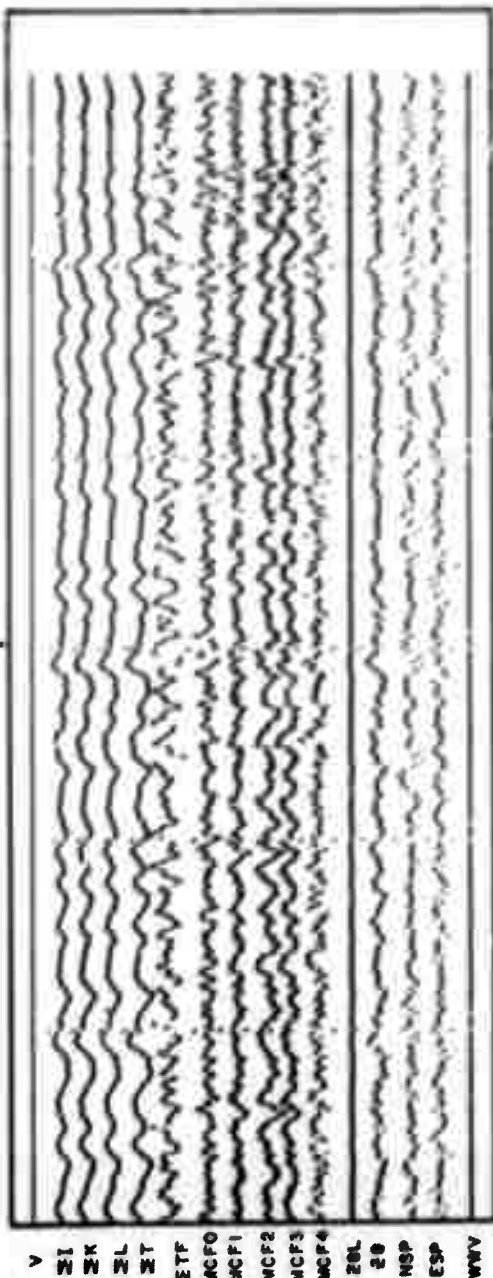
- **Figure A-9**

MCF 0 lost six coefficients; MCF 1, two coefficients; MCF 2, two coefficients; MCF 4, two coefficients. No apparent deterioration was present after the loss.

In summary, the presented results and past analysis experience at CPO indicate that little noticeable effect occurs in MCF output data during coefficient losses of the type which have normally been encountered since repair of the memory loss problem in May.

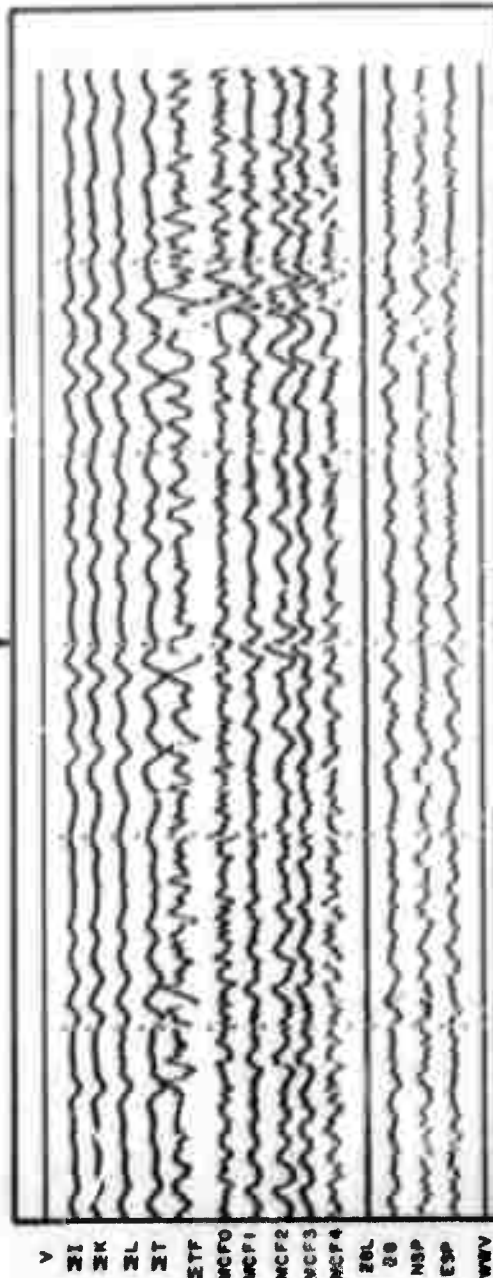


20:07:30



BEFORE COEFFICIENT LOSS

21:43:30



AFTER COEFFICIENT LOSS

AUGUST 3, 1966

Figure A-6. CPO Secondary Developer Records Before and After Coefficient Loss

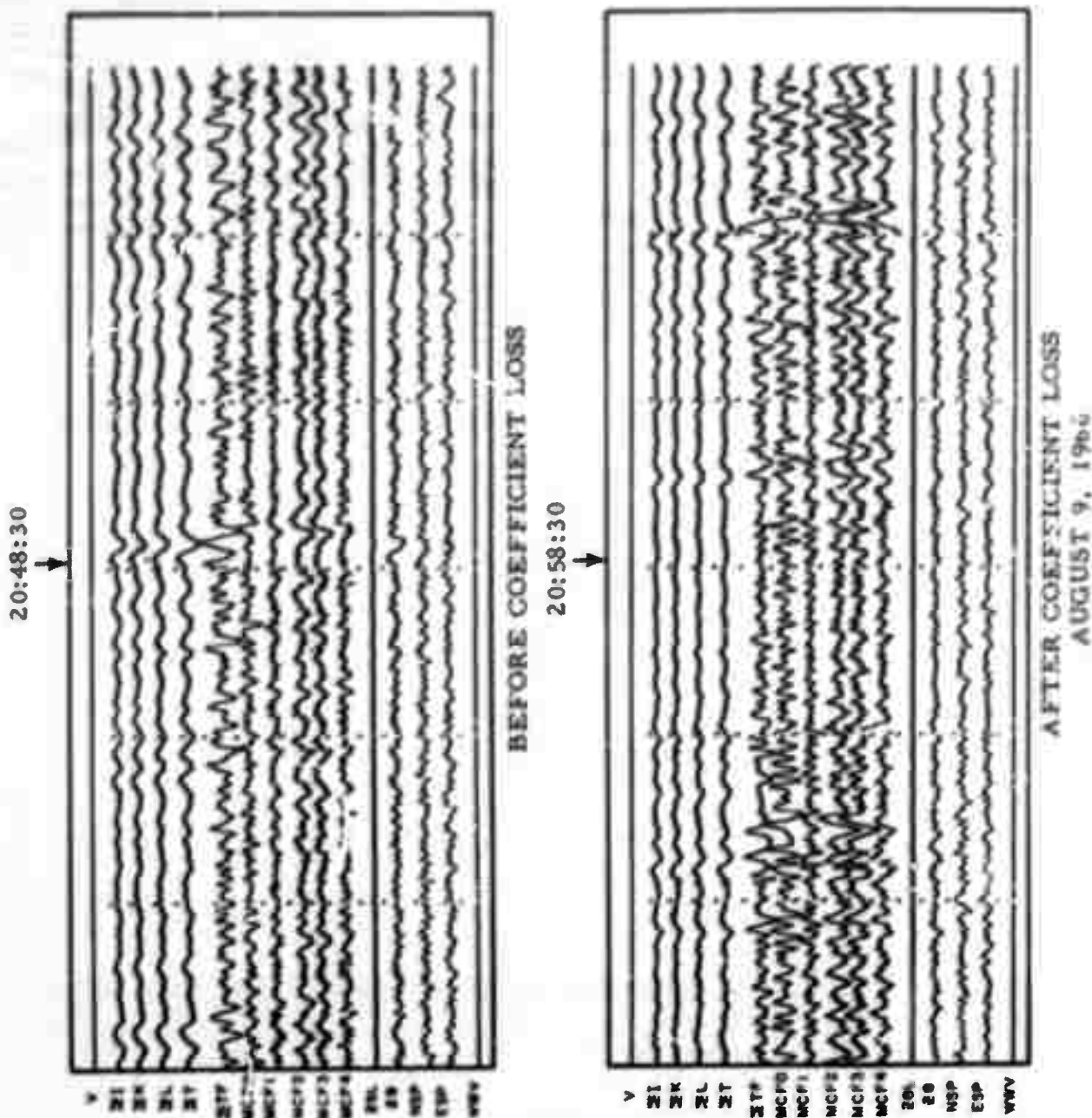
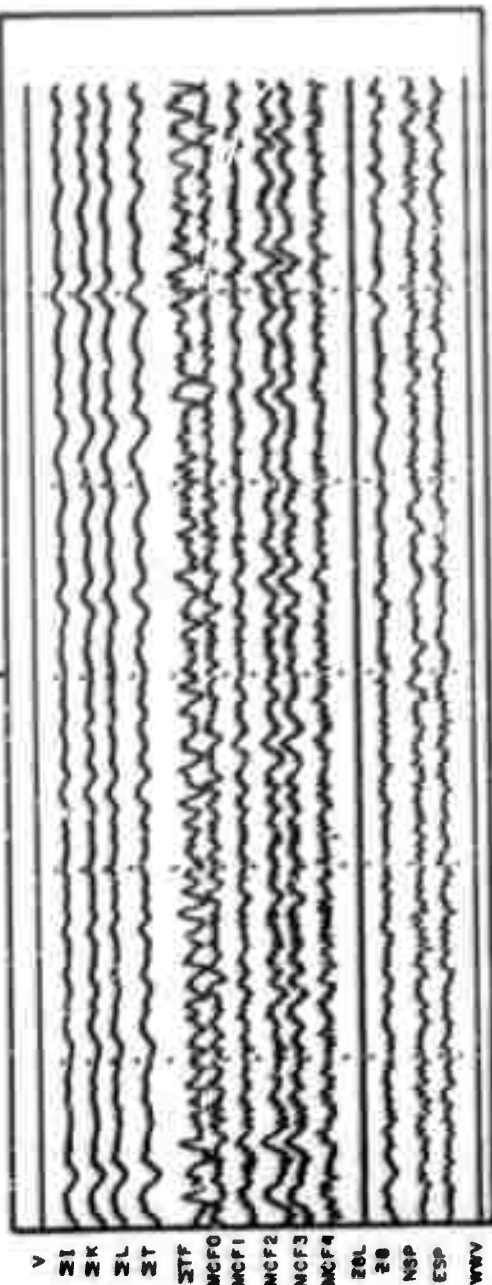


Figure A-7. CPO Secondary Developocorder Records Before and After Coefficient Loss

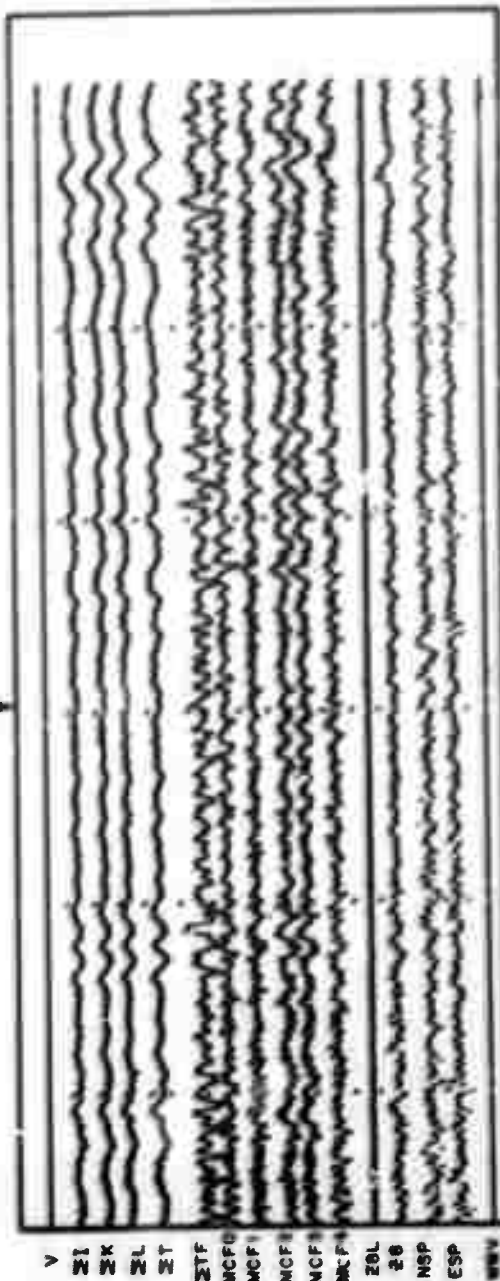


15:58:30



BEFORE COEFFICIENT LOSS

16:07:30



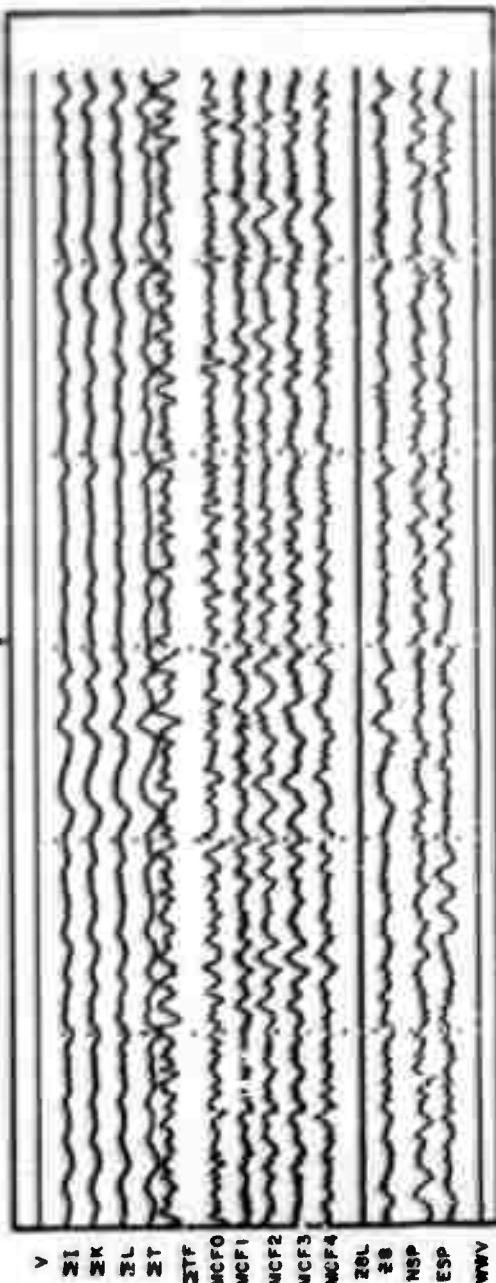
AFTER COEFFICIENT LOSS

AUGUST 12, 1966

Figure A-8. CPO Secondary Developer Records Before and After Coefficient Loss

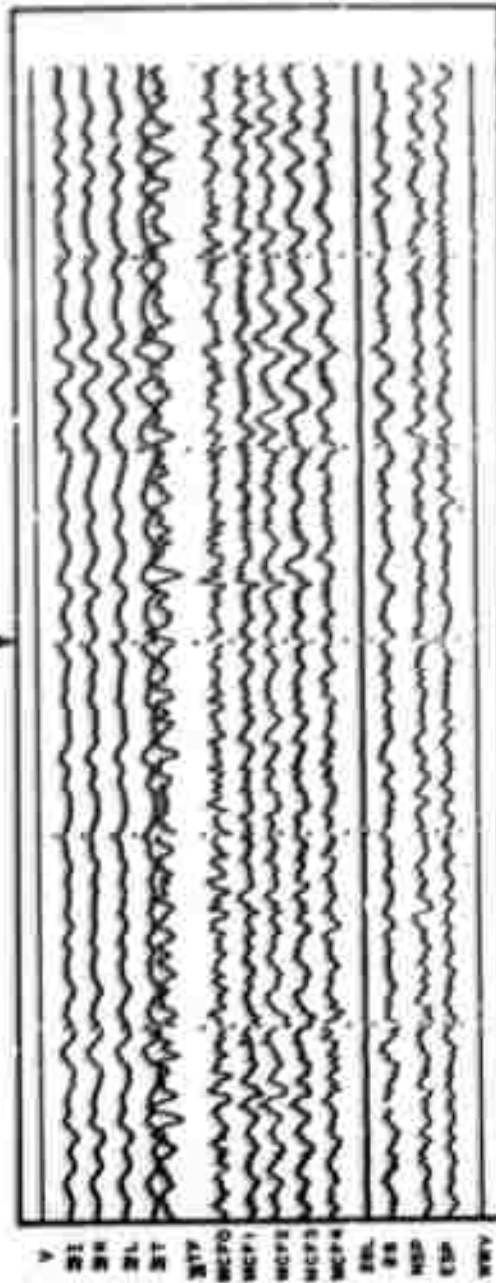


15:54:30



BEFORE COEFFICIENT LOSS

16:54:30



AFTER COEFFICIENT LOSS

SEPTEMBER 19, 1966

Figure A-9. CPO Secondary Developer Records Before and After Coefficient Loss





## APPENDIX B

EVENTS RECORDED AT CPO DURING AUGUST 1966



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## APPENDIX B

The purpose of this appendix is to present the two lists of events recorded at CPO during August 1966 and discussed in Subsection IIID.

Table 1 presents the events reported without the MCF data and Table 2 presents the events reported with the MCF output.



CPO

AUGUST - WITHOUT PROCESSOR



Table B-1  
NUMBER OF EVENTS REPORTED AT CPO  
WITHOUT DMCF DATA - AUGUST 1966

<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 1, 1966	0238059 0341354 0636460 0746524 0926382 0955085 0959579 1405210 1418184 1447397 1545295 1600577 1601543 1928137 2044384	August 6, 1966	0242554 0449304 0737190 0753125 0816406 0831214 1446364 1844451 1945471 2032091 2115297
August 2, 1966	0112017 0115547 0246575 0838505 1608296 1831481 2351227	August 7, 1966	0223137 0325525 0336298 0416390 0520375 0530214 0538363 0827039 0841100 1420048 1443090 1741433 2031385
August 3, 1966	0438186 0812200 1029000 1225480 1228514 1611341 1904553 2143461	August 8, 1966	0000487 0043430 0134255 0631440 0808136 1008005 1609555 1815256 1842178 2043462 2315456
August 4, 1966	0037016 0319217 0333476 0500531 0555415 0600525 0603403 1535230 2145516 2204567		



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 9, 1966	0009419 0117223 0125224 0209374 0227553 0346116 0615029 0637510 0903410 1042282 1118128 1254129 1924240 2240365	August 12, 1966	0027222 0035500 0437574 0931130 1019350 1041311 1445430 1452405 2026245
August 10, 1966	0213482 0514506 0531028 1252288 1301506 1304105 1326019 1534578 1630564 1729577 1754519 1758316 2129124 2135312 2223458	August 13, 1966	0048230 0410535 0448191 0805595 0905496 1507455 1524372 2142339
August 11, 1966	0035037 0446320 0526310 0539025 0956051 1017437 1055592 1331033 1452408 1505055 1519548 1621389	August 14, 1966	0545225 0715333 0756042 1004184 1041000 1149583 1349085 1534004 2301100 2309450
		August 15, 1966	0230030 0234035 0253055 0304339 0925475 1039540 1107340 1344426 1519218 1700217 1859382 1907149 1945410



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 16, 1966	0228455 0230005 0233295 0257027 0302420 0340513 0405416 0448398 0752587 1003115 1505412 1732536 1807386 2004576 2034525 2114205 2343295	August 18, 1966	1338262 1453000 1453148 1456410 1601337 1740110 1945375
August 17, 1966	0539327 0548477 0556443 0629258 0632486 1214063 1359577 1425513 1519192 1629100 1750338 2012263 2015172 2024003 2109440 2313040 2322340	August 20, 1966	0027587 0041552 0130019 0340184 0347268 0353319 0640120 0750467 0945189 1002170 1053286 1112450 1150500 1206459 1212109 1214456 1217065 1253414 1611122 1759120 2313130 2319301 2325120
August 18, 1966	0024436 0027578 0201273 0340302 0620054 0648515 0746050 0920416 1038036 1108482 1122326 1205409	August 21, 1966	0035005 0143068 0315050 0517400 0519245 0651447 0835452 0856582 0946437 1414211 1912052 2011204 2139553



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 22, 1966	0758355 0832324 1118425 1119429 1432322 1710554 1721144 1740370 1800450 1838440 2158242 2303000 2317134	August 26, 1966	0025455 0110249 0121471 0315550 0606295 0847120 1028481 1409040 1446142 2203229 2303536
August 23, 1966	0143430 0145319 0300590 0356359 0404009 0617409 0646377 0655273 0822043 1514378 1924110	August 27, 1966	0022538 0107598 0255255 0454439 0457552 0543500 1216540 1511553 1551183 1525556
August 24, 1966	0047507 0101100 0215578 0530200 0646527 0726563 1054485 1059340 1218266 1548596 2017054	August 28, 1966	0125013 0202005 0423403 0429594 0504203 0743473 0748006 0751142 1017100 1020582 1031205 1340030 1456541 1907066 2044281 2249598
August 25, 1966	0750120 0810225 1101195 1209224 2328456		





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<u>Date</u>	<u>Arrival Times</u>
August 29, 1966	0551512 0555565 0557414 0815618 1340390 1440290 1740229 1937170 2001216 2112078 2239081
August 30, 1966	0102327 0314415 0534337 0623381 0933383 1259185 1349340 1653575 1812596 2029160 2340005 2342432
August 31, 1966	0240048 0249130 0328434 0442164 0646300 0836121 0849056 0907435 0958110 1005406 1545117 1825035 1950409



CPO  
AUGUST - WITH PROCESSOR



Table B-2

NUMBER OF EVENTS REPORTED AT CPO  
WITH DMCF DATA - AUGUST 1966

<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 1, 1966	0241042 0341353 0352135 0410258 0619462 0636457 0746518 0926380 0955085 0959578 1405179 1418181 1447390 1545294 1600577 1601543 1928138 2044378 2121303 2214419 2351028	August 3, 1966	0438172 0551090 0812196 0942107 1028593 1128045 1202297 1225481 1228514 1510011 1611381 1724165 1904548 2143462
August 2, 1966	0008306 0043087 0112017 0115550 0246075 0838504 0858363 0933485 1608298 1719503 1816419 2341057 2350075	August 4, 1966	0024527 0037014 0319215 0333463 0337402 0349095 0356076 0358478 0423299 0455553 0500520 0536301 0555413 0600520 0603361 0609402 0855401 1535234 1913269 2045516 2204566 2338115 2344591



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 5, 1966	0038366 0059542 0109578 0122009 0127175 0411161 0414132 0438350 0451360 0502192 0515239 0834034 0950181 1031351 1108112 1131578 1325459 1601463 1759306 1829237 2015092 2249107	August 7, 1966	0102127 0223138 0325538 0336298 0416389 0520375 0530214 0538357 0827037 0841141 1243119 1420044 1443026 1741408 1846538 2031381 2309043
August 6, 1966	0231024 0242549 0350354 0410565 0442140 0449302 0519422 0557080 0603466 0737185 0744529 0753119 0816406 0831200 1317051 1414578 1446365 1453226 1844452 1945568 2032038 2115296	August 8, 1966	0000480 0043430 0134255 0148320 0412208 0631440 0638194 0732130 0808138 0832548 0859215 1008005 1155399 1358042 1402096 1609550 1815256 2043402 2315456
		August 9, 1966	0009419 0117238 0209352 0227551 0346117 0615025 0637532 0903410



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 9, 1966	1042281 1118129 1254119 1924241 2240344	October 12, 1966	0035492 0115535 0418010 0718253 0931126 0941236 1019349 1041311 1044323 1445427 1452397 1613580 2026244 2153547
August 10, 1966	0113482 0514506 0531013 1252288 1301533 1304104 1326018 1350286 1534579 1630563 1729578 1754511 1758316 2129123 2135302 2223484	October 13, 1966	0048236 0216425 0410530 0448182 0520550 0535087 0740377 0805591 0905496 1106448 1507456 1512367 1524371 1552036 2100459 2142340
August 11, 1966	0018205 0035505 0446261 0500521 0526227 0538574 0623194 0753307 0927157 0955593 1017376 1055546 1236057 1331067 1452349 1505056 1519549 1621388 1902594 2356128	October 14, 1966	0545224 0715334 0756039 1004178 1022080 1040596 1149581 1349084 1614255 2301101 2309445



<u>Date</u>	<u>Arrival Times</u>
August 15, 1966	0230026
	0234091
	0244476
	0253062
	0304340
	0317509
	0347591
	0432386
	0446548
	0535111
	0610531
	0925471
	1019337
	1039538
	1107337
	1111196
	1121333
	1344417
	1519216
	1700217
	1859280
	1907141
	1945406

August 16, 1966	0228452
	0230049
	0233295
	0257019
	0302420
	0340506
	0405410
	0448398
	0635117
	1003114
	1434320
	1505408
	1718277
	1807386
	2004575
	2034521
	2114207
	2343294

<u>Date</u>	<u>Arrival Times</u>
August 17, 1966	0026110
	0054453
	0120359
	0539328
	0548473
	0556440
	0629258
	0632486
	1214059
	1359578
	1425512
	1519192
	1629102
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August 18, 1966	0024429
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<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 19, 1966	0036191 0135542 0153167 0306546 0318148 0355083 0406162 0415471 0419491 0518172 0743021 0815102 0821433 1056442 1132598 1235122 1259483 1328107 1329272 1359450 1407275 1430563 1703020 1854222	August 20, 1966	1253413 1611122 1715463 1759135 2308585 2319299 2325142
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<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 23, 1966	0023336 0132017 0143432 0145318 0300590 0356355 0404010 0612409 0648154 0655273 0822219 1051261 1514377 1924116	August 26, 1966	0025451 0110241 0121464 0315542 0415313 0457248 0606294 0644560 0829008 0841432 0847120 0926219 1028482 1211297 1409039 1446136 1604513 2203186 2303534
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August 25, 1966	0623523 0738010 0750119 0810224 1101194 1209220 1940124 1948154 2328455	August 28, 1966	0135013 0141455 0202005 0211538 0230257 0423399 0429589



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
August 28, 1966	0504206 0520278 0743467 0748002 0751210 0758498 0800555 1017096 1238148 1252536 1310431 1340033 1456540 1605022 1907063 2044296 2249596 2252577	August 30, 1966	0102326 0157456 0328007 0508189 0534337 0623421 0833097 0933381 1259204 1349341 1653575 1813009 2029159 2342430
August 29, 1966	0131307 0201583 0239445 0401335 0551512 0557418 0704147 0815020 0837135 1222011 1340389 1436567 1440289 1712369 1740224 1937178 2001208 2112010 2239076	August 31, 1966	0137098 0240257 0249128 0316570 0328434 0442148 0642410 0836121 0849052 0907163 1005407 1113072 1212345 1545122 1703159 1825034 1950409